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James Black / IndyCar

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Japanese showcase?

Super GT wants its cars at Le Mans, but what would it take to do this?

After NASCAR took centre stage for the centenary running of the 24 Hours of Le Mans in 2023, could Super GT be next to run a Garage 56 car in the French classic?

That's certainly the wish of Masaaki Bandoh, the boss of the GTA organisation that runs the Japanese sportscar series. And the speed of the current generation of GT500 cars around conventional circuits would make such a prospect an appetising one indeed.

For the uninitiated, the GT500 cars built by Toyota, Honda and Nissan around a standard chassis produced by Toray Carbon Magic, essentially the same platform that the DTM used for its short-lived Class One era, are seriously quick. To give you an idea, the GT500 pole time for the Fuji round of Super GT in May was 1m 26.093s. Meanwhile, the Hypercar pole time for last year's Fuji round of the FIA World Endurance Championship was 1m28.901s, almost three seconds slower.

Toyota interest

Bandoh has been flogging this particular idea for years, but raised it again in a recent meeting with Pierre Fillon, president of the Automobile Club de l'Ouest, which runs Le Mans. Toyota, the only marque with a presence in both GT500 and Hypercar, has declared itself 'very interested' in the proposal.

The speed of the GT500 car is not in doubt, but what kind of engineering challenges would running one at Le Mans, and for 24 hours, present? We asked the only person to hold the distinction of having engineered both a GT500 car and a Hypercar, Ryan Dingle, who currently engineers the no.8 Toyota in the WEC.

'Obviously they would have to beef up the car like they did with the NASCAR,' says Dingle. 'The brakes would need to last for the whole race, which is mostly a sizing issue. If you used Hypercar brakes, it should be okay. But the Hypercars are hybrid, so with the regen they rely a bit less on the brakes, so a brake change might be necessary, like the GT3 cars often do.

'Reliability-wise, the longest race the Class One car has done is about 800km. You take a lot of kerb at Le Mans, so the floor, driveshaft and CV joints would need to be beefed up. The engine might also need to be turned down a bit. But I think it would be possible.'

While a GT500 car has the clear edge in lap time over a Hypercar at Fuji, plenty of this advantage is down to the sticky tyre war rubber used in Japan (the WEC has a single supplier). The time gain at Fuji for the GT500 comes entirely from the second and third sectors, with the two cars level pegging in sector one, which essentially comprises the first corner and the following straight.

At Le Mans, where a much higher proportion of the lap is full-throttle, it's probable that the Hypercar would gain an edge. After all, at Fuji, the GT500 car doesn't get much over 300km/h, whereas the Hypercars are routinely surpassing 320km/h on the main straight.

'I don't think the GT500 car would be as competitive as it seems on paper,' adds Dingle. 'Basically they are high-downforce cars, but with way more drag than a prototype. They would struggle on the straights, like a more extreme version of Cadillac this year!

'If you made them run a spec tyre like a Michelin they would also be slower. I think the lap times would be comparable to an unrestricted LMP2 car from a few years ago.

'If they used the Bridgestone tyres from GT500 as they are, and I think they could because the degradation isn't that much, they would be slightly faster, but probably still not as fast as the Hypercar because the drag of the Hypercar is so much lower.'

GT500 has a reputation for being one of the world's fastest closed-roof categories, but has struggled to maintain overseas interest due to time differences and the cars being ineligible for other series

Sticking points

As well as being a major technical challenge, a GT500 car would also present significant logistical hurdles. With Le Mans falling slap bang in the middle of the Super GT season, an entirely separate chassis would need to be prepared, with all the cost implications that entails, while finding the personnel to crew the car would be no easy feat, especially as most GT500 teams are also engaged in Super Formula.

For Honda and Nissan, the appeal of being represented on the grid at Le Mans in the absence of any WEC presence is clear, but questions have to be asked about whether either marque could justify the significant expense of such an effort.

For Toyota there would be no such issues, and if it threw its weight behind the plans, then it's not impossible to imagine a GR Supra, or a future Toyota GT500 car, racing alongside its GR010 Hybrid cousin at Le Mans with an all-Japanese driver lineup. The bigger, and currently unanswered, question is whether the ACO would entertain such a notion.

The speed of the GT500 car is not in doubt, but what kind of engineering challenges would running one at Le Mans, and for 24 hours, present?

'We're on the ragged edge with these cars. They're so mature now, and we're trying to squeeze that much out of them'

James Key, technical director at Sauber

Delayed breakthrough

At the end of May, Sauber was last in the standings on six points, but a sequence of strong results has transformed the team's trajectory this season

Sauber

James Key joined Sauber too late to have a major influence on the 2024 car's design, but the current C45 was developed under his watch

A mid-season update in Barcelona put Sauber back on track in 2025. **Racecar** *spoke to technical director, James Key, about the turnaround and what went wrong at Hinwil over the winter*

By CHRISTIAN MENATH

Sauber scored six points in the first eight races of the 2025 season. That's two points more than the team logged in the entire 2024 season but, in terms of performance, the new C45 was a disappointment. All six points came at the start of the season, in the rain chaos at Melbourne, when Nico Hülkenberg somehow managed to keep the car on a slippery track.

Because Sauber scored its previous four points in the penultimate race of the 2024 campaign, many hoped that signified evidence of a turnaround; that car development had borne fruit, and the team was finally on the right track. Now if it could just keep the momentum going…

'We did a lot of homework at the beginning of the 2025 season, when we recognised that again we had not delivered as much as we think we should have,' admits the team's technical director, James Key.

In the final year of the current regulations, teams brought modified versions of their 2024 cars for the 2025 season. Sauber, nevertheless, tackled numerous component improvements. The layout of the cooling system was revised to save weight and make room for aerodynamic changes. There were major modifications made to the front axle too, Sauber having switched to pull rods in 2024. When that decision was made, Key was not yet with the team. He was hired under then-Sauber CEO, Andreas Seidl, and took up his post in September 2023, the pair having previously worked together at McLaren.

After a poor start in 2023, the technical boss had to leave the Woking team but was almost certainly involved in the subsequent meteoric rise of the papaya-liveried cars. McLaren brought out its now famous Austria update and went from back marker to winning team within a year.

Push and pull

A technical director cannot take the entire car with them to a new team, but they can take their knowledge and ideas. And the C44 was not a bad basis for that. The 2024 Sauber's basic architecture was not wildly different to that of the McLaren MCL38: pull rod front axle; push rod rear axle; side crash structures in the right places for the right aero concept.

In Formula 1, however, performance inevitably lies in the details. Not all pull rods are the same, for example. 'Sauber did a brilliant job of engineering a pull rod for the C44 on the front suspension,' notes Key. 'Being in my previous team – one of the first teams to introduce that – [I knew] it is quite a hard task. It's a lot more complex, and weight demanding, and ultimately compliant than a pushrod. A pushrod is a really efficient way of transferring wheel load into the chassis, whereas a pull rod is full of compromises in every aspect.

'The team, when it was still Sauber – the smaller entity it was for a long time – took that challenge on. It's all for aerodynamics; you would never do it mechanically. They did a really good job there. It was just a few things missing, and I felt I should have made it.'

It was too late for Key to incorporate his ideas into the 2024 car, but not the 2025 version. 'There are certainly things I would have done differently, and it was a bit late to change some of the approaches I'd like to have done, though I was able to do a bit of that for '25,' he says.

Trendsetter

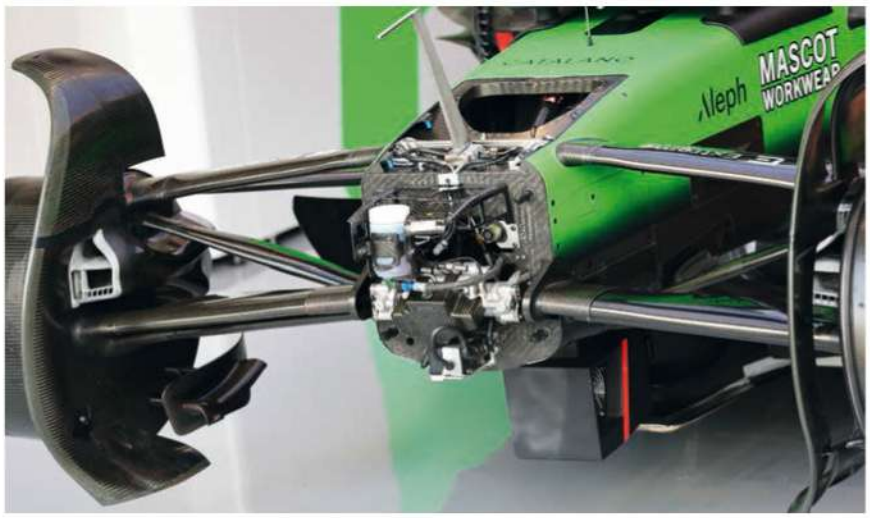
Sauber can even be considered one of the trendsetters when it comes to the rear axle. In 2022, the first year of the current regulations, the team opted to use pushrods, just like Red Bull and McLaren. But where its fellow Ferrari power unit customer, Haas, buys its engine and entire rear end from Maranello, Sauber made the decision to build its own gearbox casing (in times of budget caps, the team reasoned it is better to have your own when calculating budget). This also brings with it technical freedoms, because the rear axle is located on, and in, the gearbox casing.

That gave Sauber the opportunity to, unlike most other teams at the time, use push rods in the rear suspension as early as 2022. 'It was logical, and it was definitely the right thing to do,' says Key. 'I don't know exactly how much the advantage is as I've never done a back-to-back [test], but certainly with rear ride height being probably the most critical thing on these cars, to have a pushrod design the way Sauber has is absolutely the right thing to do.'

However, suspension layout is only a small part of the overall picture, as the technical director knows only too well: 'I think it was the right decision to have that layout. Both of those configurations are very visible, so it tends to get spoken about, but it's not really that big a deal. As long as you do the engineering okay, it's there to facilitate the way you set the car up to help the aerodynamics. The suspension basically makes the aerodynamic devices.'

What Key means by that is that suspensions in modern Formula 1 are primarily an aid for the aerodynamicists. In the current ground effect era, performance is largely determined by the floor, and so is enormously dependent on ride heights. Changes here must be made quickly and precisely, and the kinematics designed in such a way that the platform remains stable throughout. The less the floor moves in relation to the track, the better.

That, in a nutshell, is why we have seen extreme trends in F1 lately. The wishbones on the front axle have the rear pick-up points very close together at the top and bottom so the cars hardly dive when braking. The geometry counteracts the dynamic weight transfer. At the rear axle, there is a counter trend called anti-squat. This prevents the rear of the car from dipping too much when accelerating out of corners. Some teams even chose to change the pivot points of their wishbones during the 2025 season to enhance these effects.



Key was impressed with Sauber's new pull-rod front suspension on the '24 car, a layout that was retained for the C45

Consequently, this has been the big technical topic of the season. Ferrari's Spa update, with more anti-squat, brought the desired effect, while Mercedes introduced a similar modification in Imola that led the team down the wrong path. Season dominator, McLaren, also made improvements here. Sauber, meanwhile, decided against it, as Key explains: 'We're happy with what we have. We already had an anti-squat direction that I think most others who didn't have it followed. So, we're happy with our anti-squat.

'Anti-dive wise, we're in a sensible position and it isn't causing us any issues. We had some other things on the car that helped a little bit with the front ride height [at tracks] where it's all about front ride height. So we were happy to stay with where we are, simply because we already had some of those features in place, and what we had on the front was okay.

'We did make a few minor changes between last year and this year, but the gains you could find from where we are are pretty small compared to the size of the budget.'

The downforce generated by the C45 in ideal conditions was enough for decent one-lap pace but, in race conditions, it mutated into a monster

Unpredictable air

So, where did the mistake lie at the start of the season, if the basic architecture of the C45 is correct? As always in Formula 1, it all comes down to details, and aerodynamics. It soon became apparent that unpredictability was causing problems for the drivers. Starting from 12th and 19th on the grid, Hülkenberg and rookie signing, Gabriel Bortoleto, finished the opening lap of the Chinese Grand Prix at the back of the field. Both had veered off track in the dirty air of the field without any direct contact with other cars. The downforce

Sauber's drivers complained of instability in dirty air during the early part of the season

The Spanish GP update proved to be a turning point for the C45 as it delivered more downforce across a wider window

generated by the C45 in ideal conditions was enough for decent one-lap pace but, in race conditions, it mutated into a monster.

Floor updates in Japan and Saudi Arabia failed to remedy the situation. The first European grand prix of the season at Imola was supposed to mark a turning point, but it didn't happen. The document in which teams must declare their aerodynamic updates remained blank for Sauber at that race. Not a single new aerodynamic part made it onto the car. The fact the C45 was unable to seamlessly follow on from the last development stage of its predecessor had left its mark on the engineers.

'We didn't have long with the updates we did at the end of last year, but they got us some points, they got us into Q3. It was clearly a step forward,' says Key. 'Again, though, we had some surprises. It put us in a position where the car didn't handle like it did in the simulator. We weren't expecting that.

'Again, we had to go through a learning process, and the way we specified [the car for] Barcelona was really doing a lot of homework.

'At the end, it's about process and methodologies and team organisation'

Mattia Binotto, head of Audi F1 Project

'The update was actually planned for Imola originally, but we wanted to spend a little more time doing a huge amount of homework on what was blocking us from making the progress we think we should have, but that was not then appearing.

'It's not just us that have had this problem. Red Bull had issues, Aston Martin has had issues and other teams brought parts that didn't work. We're on the ragged edge with these cars. They're so mature now, and we're trying to squeeze that much out of them.'

Every second counts

It is not only technical reasons that force the teams to push themselves to the limit: 'I know people are aware of this, but it's not often commented on: F1 is so incredibly close now that if you lose a couple of tenths you go back a while, but if you gain a couple of tenths you make a big step. Historically, we've seen two to four seconds across a grid, now we've seen the whole field in Q1 within less than a second. Everyone is doing a good job, it's just that some are doing a little bit better job.

'When we had a hard time last year, it was a tenth, or two, it wasn't seven tenths off everyone else. It didn't take too much to close that gap when we found some solutions at the end of last year, but it's even closer now. There have been several races in a row where it's been less than nine tenths in Q1 between all 20 cars. This is hundredths, even thousandths [of lap time difference] between cars. I think that closeness plays its role in this.'

In the end, Sauber's update arrived two races later than planned. At the last race of the triple-header in Barcelona, Sauber brought a substantial package comprising a completely new floor, new sidepods and a front wing. The update had an impact rarely seen in Formula 1. With a little luck from the safety car, Hülkenberg moved up from 16th on the grid to fifth place at the chequered flag. Since then, Sauber has scored points in every race (at time of writing), including Hülkenberg's long-awaited first podium finish of his career at Silverstone. In the six races before the summer break, the Swiss team accrued 45 points, just six fewer than Red Bull in the same period. An incredible turn of events, considering it had only taken six points from the eight races beforehand.

Philosophy change

'We basically had a bit of a philosophical change,' Key reveals. 'We looked at a lot of the data we had from last year, from this year and we went through the whole process again. We began to coalesce into what the right approach should be, what the right metrics we should be using are, and how we need to broaden the scope of our procedures. It's far more complicated now but, fundamentally, that's what it was, to make sure we deliver 100 per cent of what we expect.'

Key's boss, Mattia Binotto, who is head of Audi F1 Project, has played a key role in the turnaround: 'We put more effort on [the] 2025 [car]. I believe it was important because you always need to keep training your muscles. It's about understanding the performance, it's about the communications between people and it's about understanding how to develop a car *and* the performance. At the end, it's about process and methodologies and team organisation,' says the Italian.

Even though the regulations will change completely in 2026, and Audi's focus has been entirely on that new era, the processes and methods now being implemented, and validated, at Sauber will help the team in 2026.

Sauber delivered its mid-season update in phases, including bringing modifications to the middle floor and diffuser in Austria (shown) and a redesign of the forward section of the floor in time for the British Grand Prix at Silverstone

Binotto and Audi CEO, Gernot Döllner, do not seriously expect to be able to compete for the world championship title before 2030, and are open about this. For Key, though, this was a decisive turning point: 'It definitely helped make pragmatic decisions. It was clear that moving that target a little bit to give the team room to breathe and expand in a pragmatic way allowed us to be a little more balanced in our approach to 2025.'

The Barcelona update improved peak downforce, but contrary to paddock rumour, also the overall laptime performance. 'It did generate quite a lot of load in very specific conditions, so the headline number did go up,' Key clarifies. However, he says that he can imagine where the rumours stem from. 'The headline number improvement is well below the lap time improvement we found. That's the right way to put it.'

This means the stopwatch shows the update better than the wind tunnel would have done. Because the downforce has been available over a wider window since the update, the result has been better driveability.

'What was really positive is that both drivers said they could feel it immediately,' adds a clearly delighted Key. 'If they say things like that, you know you're onto a good thing, as if they can feel it, they feel a lot more confident, and that's worth another couple of tenths in lap time through them being able to extract more from the car.'

Development route

The Barcelona update wasn't the end of it. Two races later, at the Austrian Grand Prix, the next stage of development of the C45's floor was already in place. This time, engineers focused on the middle section of the floor, including the edges, and the diffuser. A week later, at Silverstone, the team brought another update to the track, which saw the front section of the floor redesigned.

'All of that work was done before Barcelona,' Key explains. 'So you assume it is going to work as intended, and luckily it did. Then you say we've got a relatively strong development route with this area, so we continued developing it. We did one extra round of development compared to our original plan, which was delivered at Silverstone, just because we had momentum in these areas. It was simply development around a philosophy we were happy with.'

The Barcelona update improved peak downforce, but contrary to paddock rumour, also the overall laptime performance

Further updates to the floor show it is not only in Sauber's Hinwil engineering offices where great progress is being made. 'It's a massive task,' Key admits, in view of the challenges facing manufacturing. 'One thing we've done really well in the team over the last 18 months or so is made things like floor development an extremely slick process, from conceiving an idea through to having it on the car. If you have a really strong process, where the aero [department] is talking to the manufacturing site, it's a way of closing the joints up and you can push it through very quickly. We were nowhere when I arrived. I encouraged this direction, but it's the guys on the ground who have done the work.'

Sauber

Jonathan Wheatley (left) and Mattia Binotto are spearheading a new era for the Sauber team, whose recent results will no doubt have assuaged some of the concerns of Audi management

Sauber

Nico Hülkenberg's maiden F1 podium at Silverstone, in his 239th grand prix start, was also the first for Sauber since Kamui Kobyashi finished third at the Japanese Grand Prix in 2012

Sauber's significant 2025 in-season updates

Race 2, China
Changes to the engine cover design: the test item had a potentially positive effect on the flow field around the bodywork surfaces, improving both overall downforce of the car and aero efficiency.

Race 3, Japan
Changes to several areas of the floor: floor fence, outboard floor and diffuser. All changes aimed at having a better flow field entering the underfloor and improving flow quality all along the floor.

Race 5, Saudi Arabia
Changes to central floor geometry: aimed at improving flow characteristics around the rear floor, for efficient downforce gain.

Race 6, Miami
Updated front suspension cover design: this update regarding the lower wishbone covers was to improve local flow structures travelling all along the car.

Race 9, Spain
Further changes to several areas of the floor: floor fence, outboard floor edge and diffuser. Modifications were targeted at improving flow field conditions for the underfloor from front to back, gaining some efficiency and balancing downforce.

Further changes to engine cover design: sidepod surfaces updated to adapt to the new floor developments and associated interactions, modifying floor top surface flow conditions.

Small change also made to the transition between the mainplane and front wing end plates: local developments to improve outboard front wing performance and efficiency and to encourage better downstream flow quality.

Race 11, Austria
Changes to mid floor area, including outboard floor edge and diffuser. Designed to improve flow field conditions for the underfloor from front to back, gaining some efficient downforce.

Race 12, Great Britain
Changes to forward floor area: a continuation of recent floor development, with new forward floor geometry modifications implemented, gaining further efficient downforce.

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Aero revolution

A technical CFD analysis of F1's 2026 aerodynamic reconfiguration

By JAVIER MAYORDOMO AND ADRIAN VILLAR
VFLUID ADVANCED TECHNOLOGIES

The 2026 Formula 1 season is fast approaching, bringing with it high expectations from the fans and the weighty anticipation of a new era in the championship's history.

Much has already been written, and said, on the matter. The FIA is introducing sweeping regulatory changes that will result in completely new car architectures for next season. The primary goal of these changes is to make the racing more engaging, with closer battles, more overtaking opportunities and less predictable outcomes.

Hyperbole aside, there are two compelling reasons to look forward to 2026. First, the FIA has succeeded in bringing major automotive players such as Audi, Cadillac and Ford onto the grid, a development that's always welcome among fans and a healthy sign for the sport's future. Second, history shows that radical regulation changes tend to disrupt the competitive hierarchy, at least temporarily, offering a reset until one team inevitably finds the sweet spot and pulls ahead.

While the major changes have been widely discussed and various predictions made, it's time to move past speculation. What follows is a deep technical dive into the aerodynamic reconfiguration of F1 in 2026, and how the new cars differ from their predecessors.

To assess the aerodynamic performance under the 2026 regulations, we conducted CFD simulations using reference models. These are not based on any specific team's design (such data is both highly confidential and virtually inaccessible) but are generic geometries constructed strictly in accordance with the new technical regulations.

None of the geometries have been thoroughly developed to look for maximum performance. Instead, the intent is to provide a representative snapshot of relative performance and flow structures under the upcoming rule set.

Core objective

The core objective of the Aerodynamic Components section in the 2026 technical rulebook is to reduce both downforce and drag. A significant portion of this reduction is expected to come from the overall downsizing of the car's dimensions.

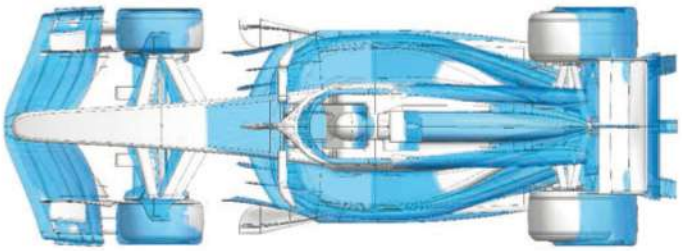


Fig 1: Size comparison of F1 2025 car (blue) vs F1 2026 (white)

Fig 2: 3D model of F1 2025 car (left) vs the new 2026 model (right)

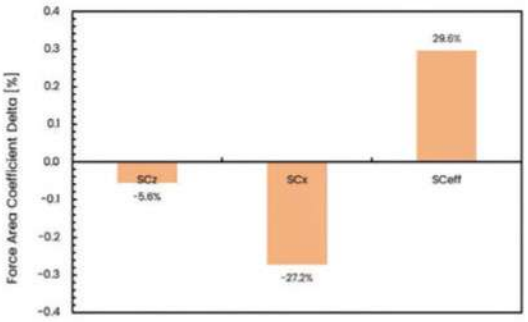


Fig 3: Downforce (SCz) and drag (SCx) reduction in 2026 car

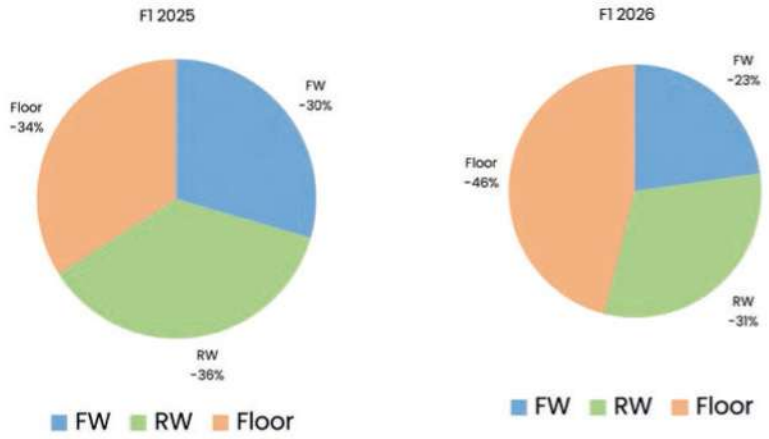


Fig 4: CFD-derived load breakdown between 2025 and 2026 car

The underfloor now [generates] 46 per cent of the car's total downforce, up from 34 per cent in 2025. This is a clear move to exploit the efficiency of ground effect

Fig 5: F1 2026 underfloor downforce (CpZ) generation

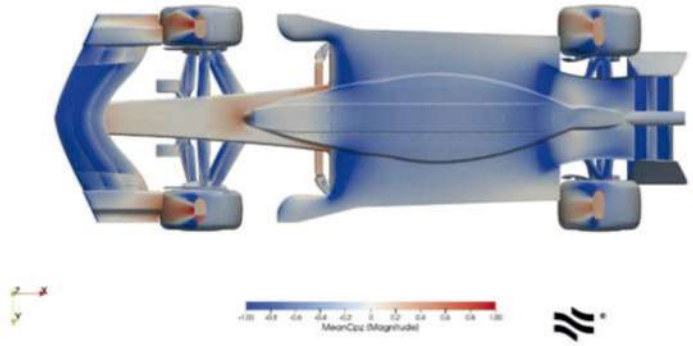
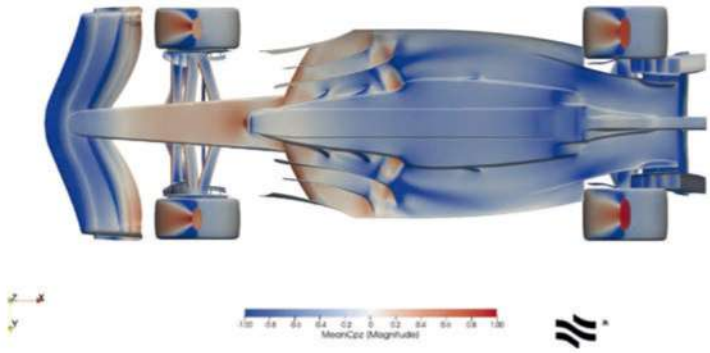


Fig 6: F1 2025 underfloor downforce (CpZ) generation



Current projections indicate the combined effect of the regulation changes could result in an overall aerodynamic performance drop of between 15 and 30 per cent. However, further from overall downforce levels, which should be similar for every team, and will undoubtedly increase as teams work to better understand the new platform, we are interested in evaluating how this downforce is generated and distributed.

Generating less downforce, but doing it in the same way, wouldn't bring any significant change to the game, just slower cars. So, the question becomes: is there any real difference in how this downforce is generated?

To evaluate this, we configured both the 2025 and 2026 reference models with identical boundary conditions: a ride height of 20 / 60mm (front / rear); four degrees of yaw, and a front aerodynamic balance set at 35 per cent. Furthermore, we set up both cars to have similar downforce levels, so we can evaluate the differences in scenarios as closely as possible.

Aero mechanisms

Our focus here is beyond simply looking at global downforce levels – which, in principle, should converge across the grid – our focus is on *how* that downforce is generated and distributed. And whether the 2026 regulations actually alter the mechanisms of aerodynamic load generation in a way that could re-shape on-track behaviour.

The first notable observation from **figure 3** is that, for nearly equivalent downforce levels (a reduction of just -5.6 per cent), the 2026 car achieves a substantially greater drag reduction of –27.2 per cent. This is directly in line with one of the FIA's central objectives: to improve aerodynamic efficiency as a means of compensating for the expected reduction in available power.

That said, the purpose of this analysis is not to fixate on overall downforce and drag numbers, but rather to understand *how* these aerodynamic shifts are likely to impact on-track performance, and how they will affect the nature of the racing itself.

Our CFD-derived load breakdown in **figure 4** shows the underfloor now generating 46 per cent of the car's total downforce, up from 34 per cent in 2025. This is a clear move to exploit the efficiency of ground effect. Correspondingly, the front wing's contribution plummets from 30 per cent to just 23 per cent. This re-distribution is not incidental, it serves two purposes. Firstly, drag management. The underfloor's lift-to-drag ratio far surpasses that of the exposed wing surfaces. As the output of the IC engine drops, reducing drag becomes critical for achieving competitive lap times with limited energy availability.

Secondly, wake sensitivity. Front wings are notoriously susceptible to performance degradation when operating in disturbed flow. By decoupling the aero balance from the front wing, cars can better maintain consistency when following closely, thereby enhancing racing viability.

One of the most critical aerodynamic shifts occurs at the front floor. As can be seen from **figure 7**, while peak downforce levels remain broadly comparable to current configurations, the location of peak suction has migrated forward. This forward displacement shifts the aero balance slightly ahead, thereby reducing the dependency on front wing loading to achieve equilibrium.

This effect directly supports another of the core objectives of the 2026 regulations. By diminishing the aerodynamic role of the front wing (now smaller and less exposed), cars become less vulnerable to performance losses in disturbed flow and less prone to front-end damage during close racing.

After more than a decade of DRS dictating straight-line performance strategies, the 2026 regulations mark a move towards fully integrated active aerodynamics

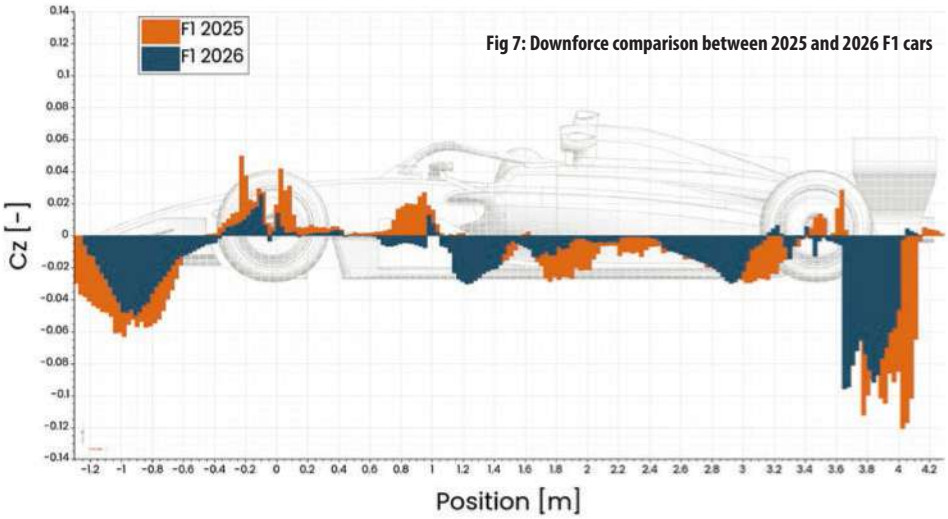


Fig 7: Downforce comparison between 2025 and 2026 F1 cars

Perhaps the most promising output from CFD analyses is the transformation observed in the wake structure of the 2026 reference geometry. When visualising the total pressure coefficient (CpT) field at a cross plane located one wheelbase downstream, we observe a marked reduction in wake cross-sectional area, coupled with a higher residual total pressure. In simple terms, the wake is both narrower and more energetic.

Wake effect

This development is far from trivial. Wake-induced performance degradation has long been one of the principal barriers to sustained close racing in Formula 1. The low energy, highly turbulent flow behind a car destabilises the aerodynamic platform of a following vehicle, particularly at the front wing, leading to a cascade of understeer, tyre degradation and lost lap time.

The 2026 aero configuration addresses this by re-balancing downforce generation towards the underfloor, making the cars less susceptible to wake interference, and by reducing outwash-inducing elements at the front end. The net result is a wake that dissipates more efficiently, with a reduced impact footprint. Crucially, this means a following car can maintain a more stable aerodynamic balance and retain a higher proportion of its downforce when in pursuit. Precisely what the FIA intended with the regulation overhaul.

While this is purely simulation-based hypothesising at present, it represents a step in the right direction. It also provides empirical support to the notion that the 2026 F1 cars may indeed enable more sustained wheel-to-wheel combat, mitigating one of the most persistent aerodynamic challenges of the modern era.

Active aerodynamics

After more than a decade of DRS dictating straight-line performance strategies, the 2026 regulations mark a move towards fully integrated active aerodynamics. For the first time in the modern era, both front and rear wings will feature variable geometry elements, allowing cars to toggle between a high-downforce (cornering) mode and a low-drag (straight-line) mode dynamically during a lap.

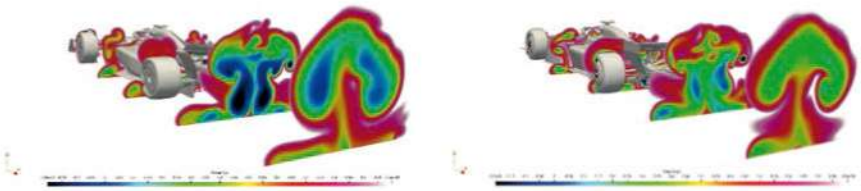


Fig 8: F1 2025 (left) vs 2026 (right) wake

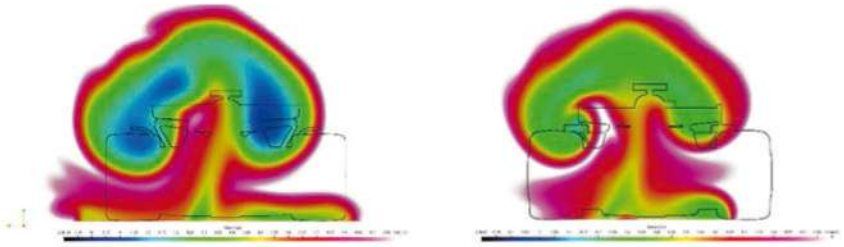


Fig 9: F1 2025 (left) vs 2026 (right) wake

Unlike DRS, which was constrained to overtaking scenarios within designated zones, and only for the chasing car, the 2026 system is accessible to all drivers at any moment within FIA-defined circuit zones. Its intent is not to facilitate overtaking directly, but to equalise terminal velocities and manage energy usage more effectively.

Each wing assembly will now comprise three elements, with the second and third flaps actuated in unison while the primary element (Flap1) remains fixed. This introduces a new axis in wing optimisation.

Traditionally, aerodynamicists aim for maximum efficiency in a static geometry, balancing downforce, drag and wake control. Now, the delta in drag between the two modes becomes an equally crucial design objective.

Consider two wings with equivalent downforce generation in high-load trim. One uses a large Flap1 and smaller active elements (Flap2 and Flap3). The other opts for a smaller Flap1, allocating more chord to the active surfaces. While both configurations may offer similar performance through corners, the second set up could provide a more pronounced drag reduction when deployed in straight-line mode.

While achieving this balance was already important in the DRS era, it becomes even more critical now that the low-drag configuration can be used over a larger portion of each lap, and on every lap. This shift elevates active drag optimisation to a level of strategic importance, comparable with that of conventional aerodynamic efficiency and load distribution.

To quantify the impact, we ran comparative CFD simulations using the 2023 car with DRS active vs the 2026 car in low-drag mode (**figure 11**).

While the 2025 system delivered a drag reduction of approximately –21.7 per cent, the 2026 architecture achieves a slightly smaller cut of –15.4 per cent. At first glance, this may seem counterintuitive. After all, the 2026 car features active elements on both the front and rear wings. However, the explanation lies in the baseline aerodynamic profile. Under the previous regulations, the rear wing contributed a significantly larger share of total drag, so activating its flaps offered a greater potential gain. By contrast, the 2026 configuration generates far less overall drag, leaving less margin for reduction when the active elements are deployed.

Fig 10: 2026 will see active aerodynamics come into play, with drivers able to toggle between high-downforce cornering and low-drag, straight-line modes during a lap. Crucially, this feature will be available to all drivers, to use within FIA-defined track zones

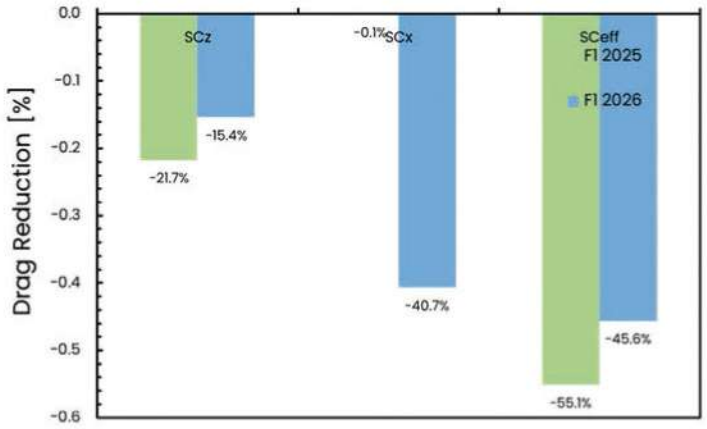


Fig 11: Comparative CFD simulations of the 2023 car with DRS active vs the 2026 car in low-drag mode

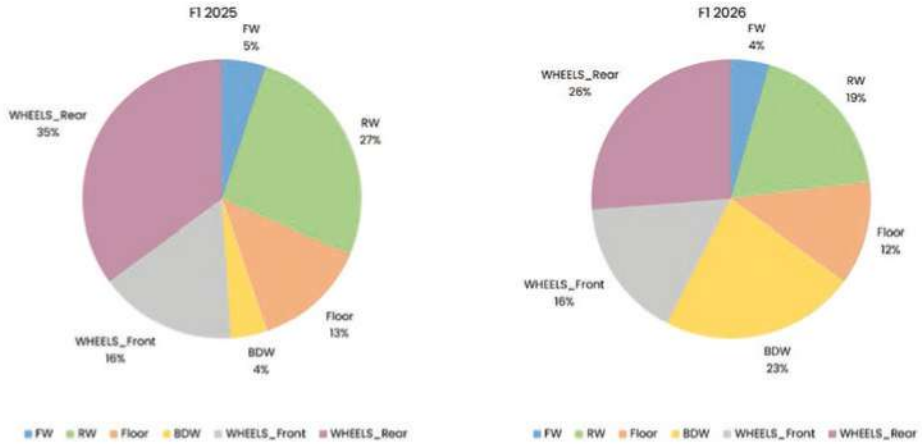


Fig 12: Contribution to total drag per part for 2025 and 2026 configurations

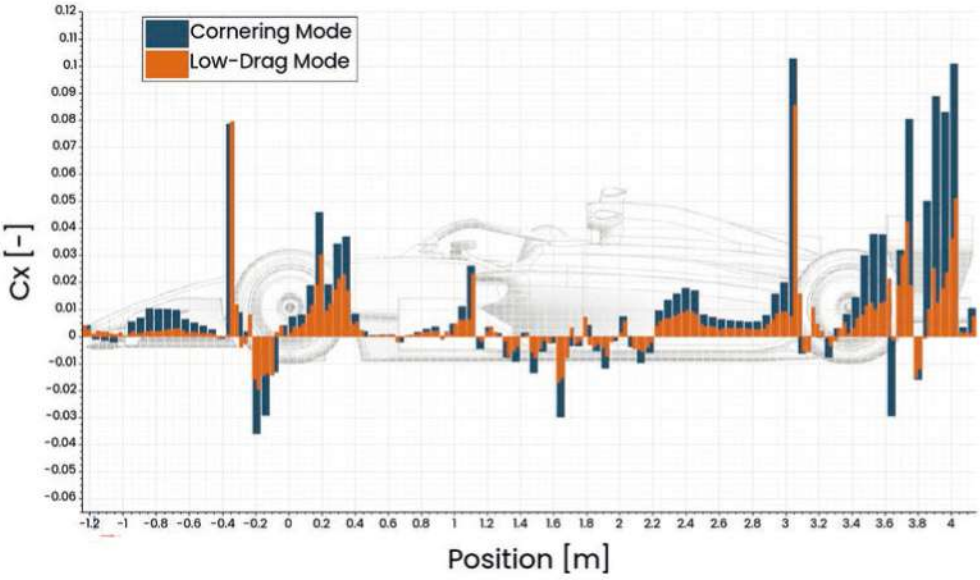


Fig 13: Drag comparison between 2025 and 2026 F1 cars

Additionally, with the 2026 car being front wing limited in achieving aerodynamic balance, the rear wing is no longer pushed to maximum downforce levels. This allows it to operate at a higher efficiency, but also means the relative benefit from opening the flaps is smaller in percentage terms.

That said, the active aero package in the 2026 regulations still delivers a substantial drag reduction and, crucially, it can be deployed over a greater proportion of the lap, on *every* lap. This not only amplifies its strategic value, but ensures the performance benefit is more consistently exploitable throughout a race.

In practical terms, this changes the development paradigm. The optimal wing is no longer the one with the highest efficiency at maximum downforce, but the one that performs best during the whole envelope of a lap, taking into account both high-load and low-drag states.

Front wing

Among all aerodynamic components, the front wing undergoes perhaps the greatest redefinition under the 2026 regulations, as it sees both its dimensional and functional significance intentionally reduced.

The new rules impose a narrower span, going back to the early 2000s' front wings, with flap extent limited to the inner face of the front wheels. This is a deliberate strategy to suppress outwash generation and reduce the lateral spread of the wake, a primary culprit in the loss of performance for following cars. Additionally, the number of elements is reduced from four to three, simplifying both geometry and flow behaviour.

CFD analyses on reference geometries reveal a drastic drop in front wing downforce contribution, from 30 per cent of total car downforce in 2025 to 23 per cent in 2026 spec. By reducing both the aerodynamic complexity and the downforce contribution of the front wing, the 2026 architecture inherently mitigates the destabilising effects of wake turbulence. Even if the front wing operates in degraded flow conditions, such as when closely following another car, its reduced influence on overall downforce and aero balance means the vehicle should retain a more stable aerodynamic platform.

Additionally, the physical downsizing of the element will potentially encourage drivers to commit more confidently to overtaking manoeuvres without incurring detrimental performance penalties.

The shift, however, comes with a new layer of complexity: actuation. For the first time, the front wing becomes an active component, equipped with dual-mode aerodynamics. Of its three elements, Flap2 and Flap3 are actively adjustable, while Flap1 remains static. This introduces a multi-variable optimisation

problem where metrics such as lift-to-drag ratio and flow conditioning must now coexist with a dynamic drag reduction potential.

Rear wing

While the 2026 regulations introduce sweeping changes to multiple aerodynamic elements, the rear wing sees a more evolutionary transition, yet one that carries significant strategic implications. The main change is the move from a two-element to a three-element assembly, with Flap2 and Flap3 actively controlled in the same manner as their front wing counterparts.

Responsible for approximately four times more drag than the front wing, the rear wing becomes the principal target for straight-line efficiency gains. The shift to active deployment, therefore, is more impactful at the rear, and its optimisation will be central to performance in the new era.

Without the benefit of ground effect, and constrained by a lower aspect ratio, it operates at an aerodynamic efficiency (L/D) much lower than that of the front wing. This disparity further reinforces the importance of maximising drag reduction when the active elements are deployed.

With the front wing's role in total downforce generation significantly curtailed, cars are expected to become front limited in terms of aerodynamic balance. Consequently, absolute rear downforce is no longer the overriding design target. Instead, the focus will shift towards maximising drag reduction during straight-line running. This likely means adopting rear wing architectures with minimal Flap1 chord, thereby allowing Flap2 and Flap3 to open more aggressively and unlock larger aerodynamic deltas between the high-downforce and low-drag states.

Front floor

Historically a hotbed of development under the ground-effect resurgence, the front floor becomes even more critical given the downscaling of the front wing and the consequent need to recover front-end load. With the front wing no longer able to serve as the only source of front downforce, the generation of high local suction at the front floor becomes essential for achieving aerodynamic balance.

The regulations permit up to five distinct sections in any given X-plane, offering teams considerable geometric freedom to sculpt vortex structures and flow control. This opens the door for intricate aerodynamic architectures, and teams will surely apply all their knowledge gained in this area during the previous years.

A key novelty in this area is the introduction of the so-called 'floor board', a mandated structure that differs fundamentally from the outgoing 'floor fence'.

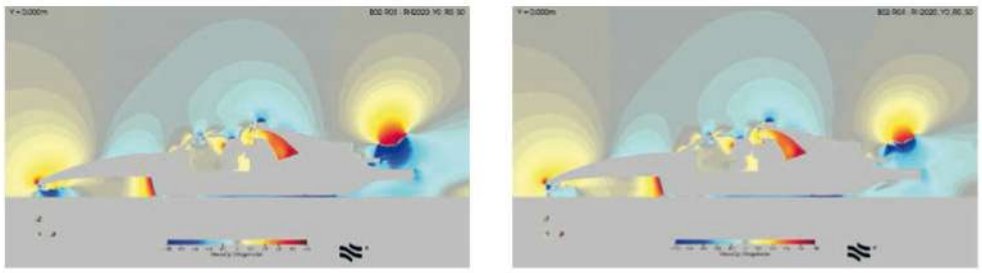


Fig 14: Pressure coefficient at Y=0 plane for cornering mode (left) vs low-drag mode (right)

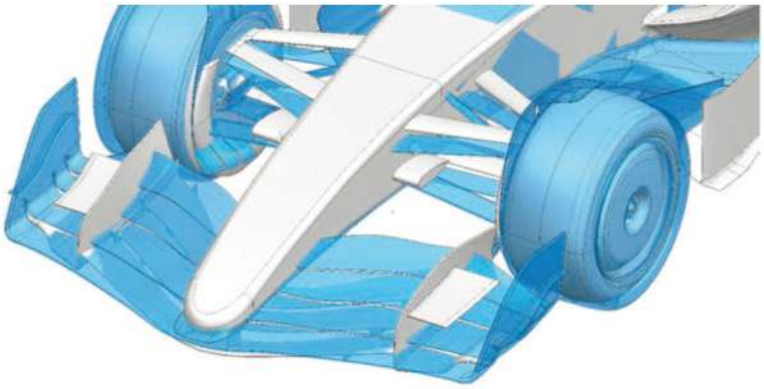


Fig 15: F1 2025 front wing (blue) vs F1 2026 front wing (white)

Fig 16: Reducing the aerodynamic complexity and downforce contribution of the front wing aims to mitigate the destabilising effects of wake turbulence. The wing will also comprise three flaps, one fixed and two active

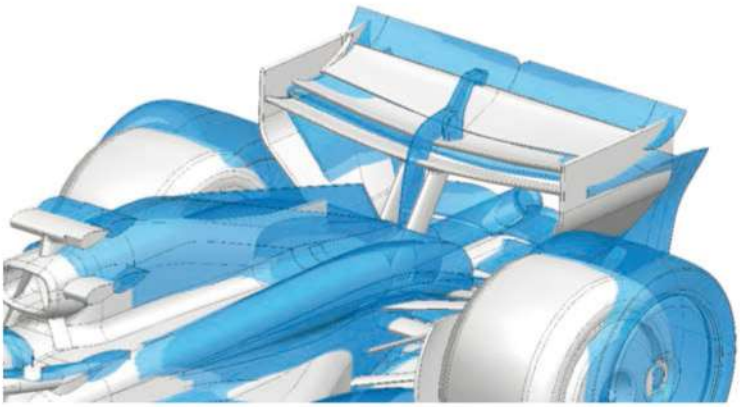


Fig 17: F1 2025 rear wing (blue) vs F1 2026 rear wing (white). Like the front wing, one flap will remain static, two active which will affect overall design concepts

Fig 18: F1 2026 pressure coefficient at plane Y=0

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Unlike the previous out-washing elements designed to deflect front wheel wake away from the car's underfloor, the floor board must be mounted above the floor surface and is required to induce an in-washing flow pattern.

This reorientation serves a dual aerodynamic purpose. First, it draws the wheel wake inward, narrowing the overall wake footprint and reducing the aerodynamic disturbance to trailing vehicles, directly supporting the FIA's aim of improving wheel-to-wheel racing.

Second, by channelling more flow towards the underfloor, the floor board acts as a passive flow conditioning device, enhancing mass flow and allowing a greater suction peak at the front floor.

Taken together, these adjustments reinforce the front floor to compensate for front wing downforce reduction and help with the FIA's objective of achieving a narrower wake.

Diffuser

For 2026, the Formula 1 diffuser steps back to be a far more contained and tightly regulated component. To achieve this, the FIA has significantly trimmed its reference volume. The exit height is roughly 100mm lower than in 2025, the usable width near the rear wheels is reduced and the forward extension ahead of the rear axle is shortened.

Classic tuning tools like the trailing-edge Gurney flap are now outlawed, while internal channelling and ramp geometry are more tightly constrained. The ramp feeding the diffuser must now start further rearward and at a gentler angle, limiting the energy of the airflow entering the expansion. This isn't just a dimensional tweak, it's a direct re-shaping of the flow physics. Taken together, the 2026 diffuser is intended to be less aggressive and less sensitive to changes in car attitude.

The 2026 season brings a wave of optimism for F1 fans. With new manufacturers joining and a radically revised rule set, founded on a philosophy of closer racing, expectations for the upcoming season are high.

The findings from this analysis broadly align with the FIA's objectives, indicating the new cars will produce a narrower, higher-energy wake and be less dependent on front wing-generated downforce. These two characteristics alone should contribute significantly to enabling closer racing.

Which design concepts each team will pursue, how far they will push the regulations, who will best exploit the dual-mode aerodynamic systems, and how the grid order may change, are all compelling reasons to be excited about what lies ahead.

Fig 19: Front floor detail of F1 2025 (left) vs 2026 (right)

Fig 20: 2026 Front floor total pressure evolution

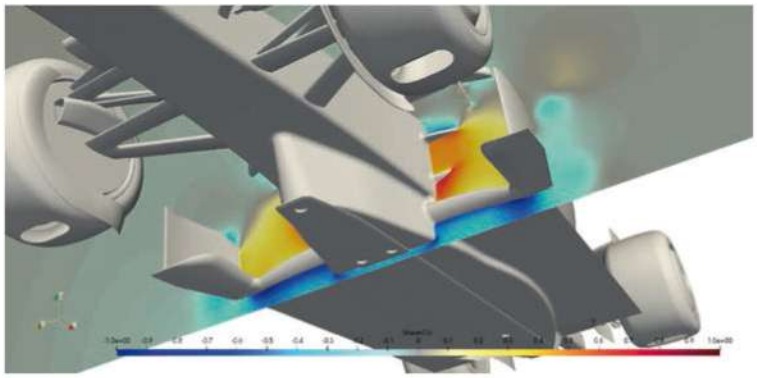

Fig 21: Front floor pressure coefficient

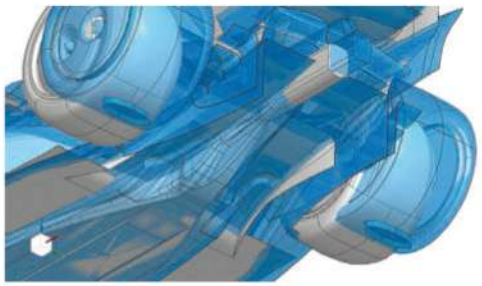

Fig 22: F1 2025 diffuser (blue) vs F1 2026 diffuser (white)

Fig 23: The 2026 diffuser is intended to be less aggressive and less sensitive to changes in car attitude

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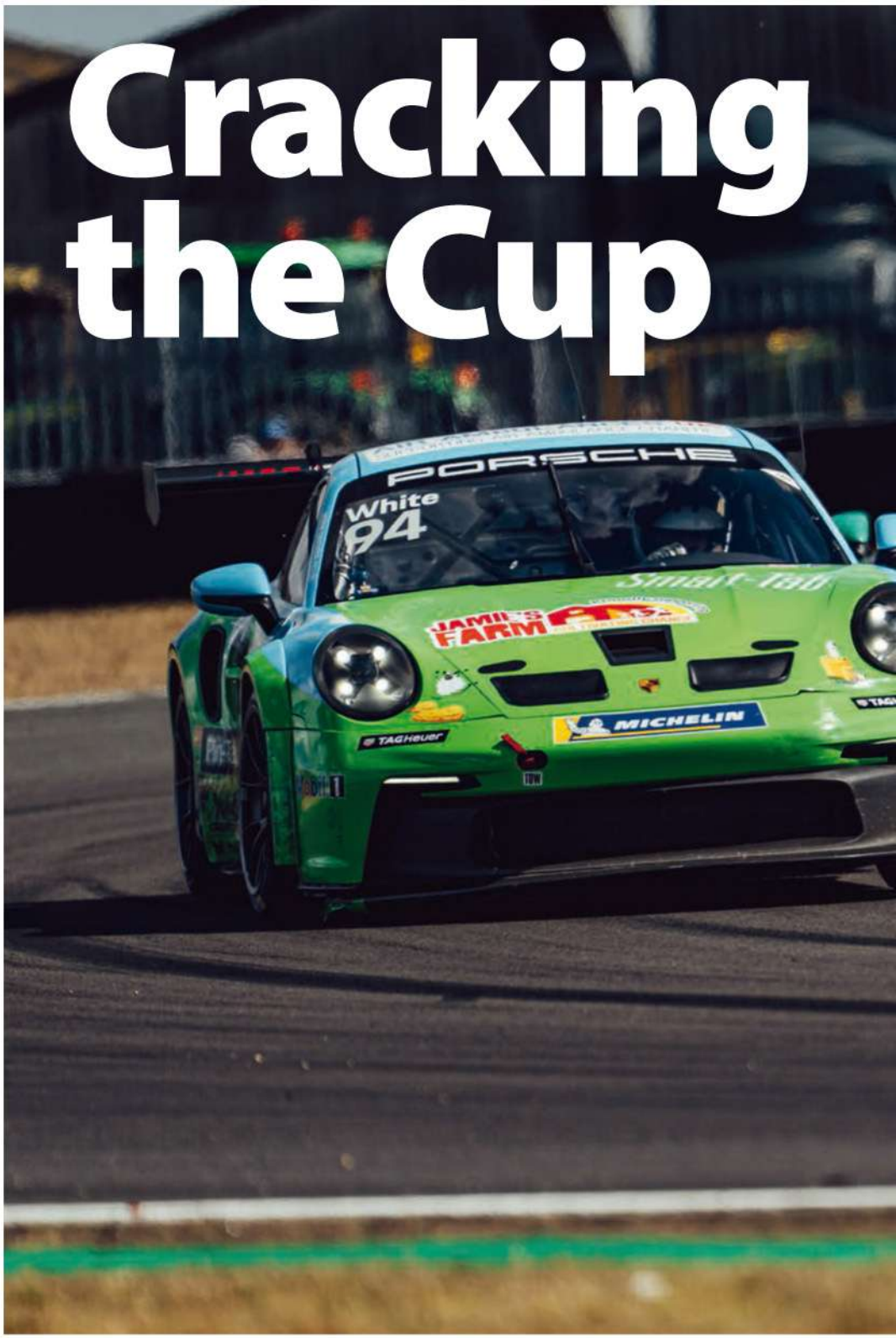
Cracking the Cup

Porsche Carrera Cup GB works hard to ensure the 911s racing in the UK's fastest one-make championship are identical. So can a skilled engineer still make a difference?

By MIKE BRESLIN



Every now and then you will hear it said of a racecar, 'if you can drive that fast, you can drive anything fast'. One car that has consistently been described in these terms is the Porsche 911, and the many iterations of this classic that have appeared on the world's race circuits since it was launched some 62 years ago.

With an engine towards the back, Porsche's most famous model has always bitten the unwary and less skilled, and it takes a certain driving style to be quick in a 911. Which is why not everyone has been able to cut it when offered an outing in one of Porsche's 13 one-make Cup championships across the globe, or the F1-supporting Supercup. It's also why those who do excel in a Cup car often progress to greater things.

Nick Tandy is a great example, having been successful in Carrera Cup Germany and the Supercup before going on to win the 24 Hours of Le Mans in 2015 aboard a works Porsche 919 Hybrid. Incidentally, he is now also the owner of the JTR team in Cup GB.

It's the success of people like Tandy that has made the Cup such a draw for career drivers in recent times, especially as many see possibilities in single-seater racing diminishing once they look at continuing beyond Formula 4 and GB3 level. That's largely because of the astronomical budgets involved, which in F3 can be around a million euros per season. Compared to that, Porsche Carrera Cup GB budgets seem a bargain at around the £300k mark, which isn't bad for this level of performance. There are also Porsche scholarship drives that ease the way for the fortunate, and gifted, few.

The influx of younger drivers has reinvigorated the Porsche Carrera Cup GB to a certain extent, though it has always been a strong series. After 22 years, it ran its 400th race in 2025 and has enjoyed a prized slot on the BTCC support bill since its inception.

It's also said to be the fastest one-make championship in the country, which is unsurprising given that these slick-shod, aero-equipped Porsche 911 GT3 Cup cars pack 4.0-litre, naturally aspirated, six-cylinder engines delivering 510bhp at 8400rpm, and 470Nm of torque at 6150rpm.

Remarkably, 5381 one-make 911s have been sold across the globe, making it a likely contender for the world's top selling racecar. The current variant is of the 992 first generation, though that is soon to be replaced (see p28) and, while this model been used in the UK since 2023, 1130 of these have been built by Porsche since 2020.

For 2027, a new car based on the 992.2 will be introduced into Cup GB, and to Supercup next year, this time simply known as a 911 Cup.

Form and function

For now, though, both the 911 GT3 R used in global GT3 racing and the Cup car confusingly share Porsche's own 'GT3' moniker. However, they differ in many respects.

The Porsche Carrera Cup GB has been entertaining motorsport fans since 2003, and held its 400th race this year at the Snetterton British Touring Car Championship meeting in May (shown)

For instance, the 911 GT3 Cup has no driver aids, although on the amateur (Am) class cars (there are also Pro and Pro-Am classes) ABS is allowed. There are other differences too, chiefly to do with the amount of work teams may carry out on each.

Alejandro Jimenez, a race engineer who, as well as working on the Porsche Carrera Cup GB technical team, also plies his trade in GT3 racing, explains: 'GT3 cars have big wings, splitters and diffusers that really work. Our splitter with the Cup car is made of plastic and, while it has some effect on aero, it's not the same as a GT3. The GT3 is all based on downforce. Also, suspension geometry and kinematics for GT3 is different to these cars. You can change the whole kinematics of the car [in GT3]. You can play with roll centres, with anti-squat, anti-dive. There are so many more things you can do with GT3.'

But then ultimate performance isn't really what the Cup car is about, because in Cup GB the most important thing is that it's strictly policed so the cars are equal and the racing is close. This is fundamental to the success of the series, and keeping this playing field level is down to people like eligibility scrutineer Simon Holloway. 'General scrutineering in a lot of the UK now is 25 per cent of cars each weekend whereas, because we're supported by the manufacturer, we do a 100 per cent check, which I think is a good thing,' he says. 'The teams know we police it very tightly, and it's how we run such a tight championship. It's really down to the drivers, the teams and their set-up.'

'All our cars run data logging. Anything that was an anomaly would show up really quickly; we could flag it and then investigate further'

Simon Holloway, eligibility scrutineer for Porsche Carrera Cup GB

Work for the teams does not, incidentally, include fettling the engine. 'The engines and ECUs are sealed,' continues Holloway. 'So teams can't do anything with them. There are things on the periphery, like air filters and throttle bodies, but we check those on a regular basis. Also, all our cars run data logging. Anything that was an anomaly would show up really quickly; we could flag it and then investigate further.'

Engines will run for an impressive 100 hours between rebuilds, with 120 hours for gearboxes, which are Porsche six-speed, sequential, dog-type units with an electronically-actuated paddle shift, all of which is also sealed. Other transmission components include a mechanical LSD and a three-plate sintered metal racing clutch.

Limited scope

Suspension is double wishbone at the front and multi-link at the rear, both with limited scope for tuning, while the dampers are spec items that cannot be adjusted.

'It's been a fixed damper for some time, which is quite common in single-make championships, because often the manufacturer will develop a damper to the optimum for the vehicle anyway,' says Holloway. 'It takes out one of the variables that the teams could adjust, or do something different that is outside of the regulations.

'It's also another easy thing to police, as we can take a damper off and put it on a damper dyno to check the curve to make sure it's not been adjusted. Sometimes we'll also seal a damper and take it away, and I can seal other components on the car and take them away for checking as well.

'Also, with Porsche, we run a scrutineering app, which we have on a tablet. That is something unique to the championship,' Holloway adds. 'With that app, every race weekend, we do our 100 per cent checks on the cars, looking at both safety and eligibility. We'll go through all the safety equipment in the car to make sure it's up to date. We then upload that to Porsche Germany at the end of the weekend. So they get the data about what we've checked on the car, if anything's coming to the end of life. And we have that history, too. So I can go back and check what

A Cup car in the scrutineering bay. Porsche has full technical control over the championship and undertakes 100 per cent inspection at every round, which is unusual in an era when, on average, only 25 per cent of cars are checked

In the traditional (for a 911) rearward position sits the car's naturally aspirated, 510bhp, six-cylinder boxer power unit. The engines, ECUs and six-speed sequential gearboxes are all sealed so they cannot be modified in any way

Dampers are also control components, which means suspension tuning is restricted to anti-roll bar, toe and camber adjustments

Perhaps the most widespread tuning method is altering the rake, with a higher rear giving a stronger front end. This is considered the most effective tweak for the pro driver

different scrutineers from the championship did on the last weekend and then compare it with what I might do this weekend.'

Sticking with safety, the Cup car has many of the features seen in its GT3-spec cousin, such as a removable roof hatch for driver extraction. Naturally, there is also a full rollcage, designed to protect a co-driver too, because coaches will often be employed as knowledgeable ballast on track days.

Experience pays

Despite the strict policing, there are still things a race engineer working in Cup can do to the car, and it's telling that the experienced teams do tend to be the most successful.

'I think, sometimes, when you've got fewer things you can do, it makes the small changes you can make more important,' says Barry Horne, team manager at title-winning squad Team Parker Racing, and champion of the inaugural Cup GB season in 2003. 'They're not like a GT3 car, where you can change so much that you can end up getting lost, or needing to buy in serious expertise in different areas. Here, to give the driver an edge, everything has to be as close to perfect as possible.'

As Horne says, that perfection needs to be holistic, but one thing that does seem to be given a great deal of attention is the rake along the car, although always within the limits of the minimum ride height.

'You'll go down to your minimum settings on the ride heights and then work it from there, putting a bit of rake in to make sure the front bites, putting a bit of weight over the front,' explains Horne. 'Then, if the driver says the rear has started to get a bit edgy, we would maybe come down a turn on the rear. You'd be amazed, even just half a turn, drivers can really feel that.'

With no scope to play with dampers, the other suspension components also come in for a lot of attention. 'Everybody plays a lot with anti-roll bars,' confirms Jimenez. 'And camber and toe adjustments [although there is a maximum camber setting]. The thing you see them playing with most though, is ride height at the rear, to change the rake.'

Changing rear ride height will often be done in conjunction with a rear wing tweak, but otherwise aerodynamic tuning is also severely restricted. 'It's limited, because on a Cup car, in general, you don't have a way of really adjusting your front aero,' says Will Parkinson, chief engineer at Parker Racing. 'So it's just a method of balancing the car, instead of finding a level of downforce, like you would with a formula car.'

'They're not like a GT3 car, where you can change so much that you can end up getting lost… Here, to give the driver an edge, everything has to be as close to perfect as possible'

Barry Horne, team manager at Team Parker Racing

That balancing is mostly via the carbon-reinforced plastic rear wing, which sits on a swan neck, and has 11 settings. The car also has a flat floor and a rear diffuser, both of which presumably react to rake changes.

Under pressure

Slick tyres are from Michelin, and these are also strictly controlled, with three new sets and two used sets available throughout a weekend (if wets are needed, there is no limit on the number used). When and how the slicks are used is crucial, though.

'It's mandatory to use new sets for qualifying, so we [the Porsche tech team] can see fastest laps,' says Jimenez. 'Normally, teams use two used sets for [Friday pre-event] testing. Some people use a new set as well, just to see if the car is where they want it to be for qualifying, and they will keep that set for one of the races, because it's going to be an almost fresh set. Then you go to the qualifying and normally you do two outings. The first one is still on your used set, as the driver needs to adapt to the track. This is because the track conditions change a lot.

Front splitters do not offer much in the way of adjustment, which means the different rear wing settings are generally used to balance the car along the chassis rather than for overall downforce gains

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The carbon fibre-reinforced plastic rear wing is mounted on a swan neck and has 11 adjustment positions. The car also has a diffuser

'Tyre pressure is critical on this car. Michelin give the cold pressure you need to start running. From there on, you're going to start tuning your car'

Alejandro Jimenez, Porsche Carrera Cup GB technical team

TECH SPEC: Porsche 911 (992) GT3 Cup

Chassis
Lightweight body with intelligent aluminium-steel composite design; rollcage; removable rescue hatch; carbon fibre reinforced plastic doors

Engine
Sealed, naturally aspirated, 3996cc six-cylinder boxer; single throttle butterfly system; intake manifold with two resonance flaps; dry sump lubrication with oil-to-water heat exchanger; Bosch MS 6.6 ECU
Max power: 510bhp at 8400rpm; max torque: 470Nm at 6150rpm; max revs: 8750rpm

Transmission
Sealed Porsche six-speed, dog-type gearbox; electronically-actuated paddle shift; mechanical LSD; three-plate sintered metal racing clutch

Suspension
Double wishbone front suspension, adjustable for ride height, camber and toe; multi-link rear suspension, adjustable for ride height, camber and toe; forged control arms and top mounts; heavy-duty spherical bearings with dust protection; non-adjustable control dampers with motorsport-specific valve characteristics; double blade-type adjustable anti-roll bars

Aerodynamics
Carbon fibre-reinforced plastic rear wing mounted on swan neck with 11 adjustment positions; front splitter; flat floor; rear diffuser

Brakes
Monobloc racing brake calipers (six-piston front, four-piston rear) with anti-knock back piston springs and 380mm x 32mm steel brake discs; aluminium disc bells front and rear; brake bias; ABS available on amateur-class cars

Electronics
Full colour 10.3in TFT dash display; Porsche data logger; Porsche power box; digital touch panel with multi-colour backlight

Wheels and tyres
Front: 12J x 18; rear: 13J x 18; Michelin control slicks and wets

Dimensions
Length: 4585mm; width (front axle): 1920mm; width (rear axle): 1902mm; wheelbase: 2459mm

Weight
1260kg without driver, 1350kg with driver

We are running Michelin, but there are people [on the TOCA package] using Goodyears, and there are others running Pirellis.'

This means the track changes through the day as different compounds are put down. 'When we go to qualifying, the first time out, we don't normally see the fastest lap,' continues Jimenez. 'We don't see the pole position, because they need to adapt to a track and they need to understand where the grip level is. The second time they are out, that's when you will see the fastest laps.'

There is also a minimum tyre pressure to consider: 'We are the only Cup market that uses the full Michelin recommendation for minimum pressure,' says Eddie Corr, technical manager at Porsche Carrera Cup GB. 'When that regulation came in, the drivers perhaps didn't like it so much. They were using their old knowledge of the N2 tyre on the previous generation car [often run on lower pressures]. This is an N3 tyre and it's far superior. Michelin put in a lot of work and the new tyre really suits the car well. We felt that it was the right thing to adopt the minimum pressure regulation, because it aligns us with all top-level FIA formulas.

The fact other formulas, including Supercup, didn't run it was of no interest to us. We've got a far superior tyre and a very robust regulation. That's why we can go to Thruxton with these cars.'

The significance of that is the high-speed Thruxton circuit is famously hard on tyres.

However, just because there is a minimum tyre pressure doesn't mean there is no advantage to be found in tweaking the psi.

'One thing that's very important, that you don't see all of [the teams] working on a lot, is tyre pressure,' says Jimenez. 'Tyre pressure is critical on this car. Michelin give the cold pressure you need to start running. From there on, you're going to start tuning your car. But you see most of them just running the minimum cold pressure, they don't understand how to really work on the tyre pressure side. Because it's not just running the lowest point, the air in the tyre is damping. So, if you have more air, you will be stiffer, a bit less air and you will be softer. You can play with that as a damping control, but not many do. But some of them know.'

Amateur assistance

It will be clear from much of the above that a great deal of the set-up work with these cars is driver dependent for, while speed is vital, these cars can bite. This is, of course, much more of a factor when it comes to the amateur drivers, yet Horne says there is not always much difference between the set-ups on the Pro and Am-class cars at Team Parker.

'Sometimes we'll maybe have the Am car a little bit softer, so it's less edgy, because sometimes a quick car is maybe not the easiest to drive,' Horne says. 'The main difference, though, is that Am cars have ABS.'

The multi-point ABS system used in the amateur class allows for varying degrees of assistance, depending on driver preference and weather conditions, while there is the option, for the more confident amateurs, to simply switch it off. Most Ams do run with the ABS, though, and some will certainly also prefer a more driver-friendly set-up.

Michelin control rubber has a minimum pressure, but the more knowledgeable teams will adjust psi above this, which offers a level of damper tuning through the air in the tyres

People involved in other series will also know that if you've tamed a Porsche Cup car, and won races with it, you have what it takes to be a top racing driver

'If you want to make the car safe for the [am] drivers, you will go for understeer,' says Jimenez. 'It's as simple as that. The good thing about understeer is, if you are losing the car, you just lift the foot [off the throttle] and then you can adjust the steering. But quick cars are reactive, they are agile. If they are like that, you need to have a loose rear and very strong front end. Those cars are very quick, but sometimes they are unpredictable. A pro driver can countersteer and control the moment, but an am driver that doesn't know what they are doing so well, and is just attacking the corner, as soon as they have a snap on the rear, they won't control the car.

'So, for people who are starting, it's always understeer, it's safe. You lower the rear and the platform is lazy, it doesn't want to turn. But when you have good drivers, you give a bit more rake to the car, less wing and loosen the rear and the car will turn immediately.'

This is an important point, because these cars need to be driven on the edge for success in this highly competitive championship. 'You need to hustle the car,' agrees Jimenez. 'You need to be sharp on the steering, you need to be really strong on the brakes and you need to be very quick on the throttle. The car will then be very reactive. But you also need to be very good with the hands or you will lose the car very quickly.'

Brake test

One driver who is very much at home with just such a set-up is James Wallis, who has a background in junior racing and GTs and is a Porsche Carrera Cup GB Junior driver, now in the second half of his two-year, factory-backed scholarship. It was Wallis who had the honour of winning the series' 400th race at Snetterton earlier this year, his maiden Cup victory, and the JTR driver has no doubt as to what the secret to going really fast in these cars is.

'Seat time, I think that's the main thing,' says Wallis. 'The more time you're in these cars, the better. That said, a lot of the lap time comes from the brakes, because we [pro drivers] have no ABS. Ultimately, whoever trusts that brake pedal the best, and has the best feel so they don't lock the tyres, is going to be quick. And we're hitting probably 60 to 70bar [pressure on the brake pedal] in the dry.'

The driver's office features hi-tech touches such as a full colour 10.3in TFT dash display and digital touch panel

These brakes are from Brembo, with 380mm x 32mm steel discs front and back and six-piston calipers on the front and four-piston on the rear. The drivers also have an in-car brake bias control. Yet, while not locking up the anchors is vital when it comes to driving a Cup Porsche, drivers also need to be disciplined with the throttle pedal, as with no traction control it's quite easy to slide a 510bhp, rear-wheel drive car around.

'You can overheat these tyres very quickly,' says Horne. 'Especially in the race, as it is a 30-minute sprint. I mean, you're going flat out, but you've also got to be aware that if you slide these too much your rear tyres are going to balloon up pretty fast. Certainly, locking up is a no-no, but sliding the car too much is a no-no, too. If you do slide the car that just makes the [tyre] surface temperature go through the roof, and then you'll be four corners down the road until you can settle them down again and playing catch up from there on. So, a lot of it is tyre management.'

Tyre management, but also, for the teams, driver management. 'I think we know what we're doing with the car, and sometimes the drivers need to drive it in a little bit of a different way,' says Horne. 'That sometimes means getting these drivers to change their approach ever so slightly. But then, when they've got it, they've got it.'

Porsche Pyramid

If they do master the technique, a good driver can go far, for the Cup is certainly on the Porsche 'Pyramid of Motorsport', and that means a future as a Porsche factory Hypercar driver is not an impossible dream for those racing in the UK or one of the European championships. There's a bit more to it than that, because people involved in other series will also know that if you've tamed a Porsche Cup car, and won races with it, you have what it takes to be a top racing driver.

'We stick with a formula of no driver aids,' says Corr. 'So it's a really proper car. It's got good aerodynamics, good power-to-weight ratio and it's rear engine. As we always tell our own scholarship drivers, and everybody else who's learning to drive a Cup car, we've never heard anybody getting out of one and saying, that was easy. It's a proper driver's car.'

With big power and no traction control, 911 GT3 Cup cars are notoriously difficult to handle. Drivers consequently need to treat them with respect and limit power sliding to help conserve tyre life. If you master it, you could go far

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The new Porsche 911 Cup 992.2 replaces the 992.1 model, which made its debut in 2021. The car will launch in Porsche Supercup next year, and gradually arrive in national competitions after that

Thine Cup overfloweth

Porsche has introduced its new 911 Cup car. It's based on the second generation 992 and, says the manufacturer, is a step change from the previous version

By ANDREW COTTON

Porsche's new 911 Cup car has big shoes to fill. More than 1100 examples of the first-generation 992 Cup car have been sold around the world, and the German manufacturer is expecting a similar sales figure for the replacement model. It's a big task, as the chassis are assembled on the same production line as the regular 911 road cars, but Porsche says it will build five vehicles per day, 25 per week, with the factory working at full capacity.

Not only will Porsche have to produce the cars, but teams will also need time to adjust to the new aerodynamic concept that governs it, compared to the previous 992.1 generation. There are three radiators mounted at the front, as before, but the central radiator has moved to the rear of the front luggage compartment. That means less chance of damage in the event of an accident, better weight distribution and improved airflow through the car.

Porsche has worked closely with French tyre company, Michelin, to develop the rubber for the new Cup car. Bastian Buus, Laurin Heinrich, Klaus Bachler and Marco Seefried were the test drivers at tracks, including Lausitzring, Monza and Weissach

Air is now channelled to the front brakes through two new cooling ducts in the nose, the brakes having been increased in width, from 32 to 35mm. To help evacuate the air, louvres over the front wheels are pronounced, and flow out contributes to an increase in downforce over the front wheels.

Improved aero

'The aero on the front axle was a negative point that the customers were feeding back from the first-generation car, so this was a big task to work on, in combination with the braking system that we wanted to upgrade anyway, because the car comes with ABS and traction control from the factory,' says Christoph Werner, product manager for the 911 Cup.

Consequently, a splitter – taken from the company's GT3 car – combines with turning vanes located downstream to further increase front-end downforce, reducing the inherent understeer characteristic of the 992.1 model.

Adjustments have been made to the rear as well to preserve balance, and Porsche says the net result is an overall improvement in aero efficiency: 'We have optimised the airflow, so the exit of the [central] cooler is way more smooth out of the car,' says Jan Feldmann, 911 Cup project manager. 'We made it possible to split the air going into the car, so the top half of it goes into the cooler and the bottom half leaves some space for brake cooling, and we take that air directly from the front.'

Running costs

Despite the upgrades, a lot of effort has been made to control costs to the customer, and the brake package was a key point here: 'If you were running a first-gen car with ABS, the wear rate was quite high,' acknowledges Werner. 'Now, with the wider brake disc, we have reduced the disc bell a bit, so we have more friction surface on the front disc. In combination with a new compound of brake pad, and with new geometry, that contributes to way longer running [time].'

'The aero on the front axle was a negative point that the customers were feeding back from the first-generation car, so this was a big task to work on'

Christoph Werner, product manager for the 911 Cup

Porsche estimates the improved pads will last double the mileage of the old versions.

The Bosch M5 racing ABS system will be fitted to all 911 Cup cars, with enhanced data processing capabilities to interpret input from the new acceleration sensor, which offers additional signal detection. The advanced software will also alert the driver in the event of a leak in either of the two brake circuits. Additionally, the brake fluid reservoir has been enlarged, making it suitable for long-distance racing.

Further upgraded electronics include a tyre pressure monitoring system that now displays tyre air temperatures on the central dashboard display, pit lane time measurements and a pre-kill function that automatically stops the normally aspirated, four-litre, six-cylinder boxer engine when the car comes to a standstill during pit stops.

The new Porsche 911 Cup is priced at €269,000 (approx. £232,800 / $312,200) plus country-specific tax. Porsche has dropped GT3 from the Cup car's name, and that designation will now only be used for cars in open-brand competition

Porsche has stayed away from introducing adjustable dampers to keep the costs of buying and running the car as low as possible. This decision comes despite pressure from teams competing in the Porsche Supercup to have adjustability. Werner explains: 'We now have 35 one-make championships globally, and the other markets are saying to keep it as simple as possible. The car needs to be driven safely, and the running costs need to be in a proper range, so on purpose we decided not to go to adjustable dampers.'

Recycled carbon

Porsche has made extensive use of carbon fibre throughout, but has focused on re-using otherwise discarded material, notably on the redesigned rear deck and doors, but also other non-stressed parts, including the cockpit. 'The base material is left over from other production processes,' says Feldmann. 'If you make a carbon fibre part, you have your lay-up and then you start with scissors, cutting away the outer parts. We are using those leftover parts.'

Engineers shred the discarded carbon and then combine them with a bio-based resin to create new parts. 'In strength and lightness they are close, but they are not the same [strength] as a carbon fibre part,' notes Feldmann. 'What we see is on one side the sustainable fact that we are making use of the leftovers, and on the other side we can keep the costs of those parts down.

'We see part price increases a lot in carbon fibre parts, and by doing this we can work against that, and not have the increase in prices for those components that we have with regular carbon fibre parts.'

Porsche has also worked on smaller details, such as adjusting the steering stops to allow a tighter turning circle, something that is useful in the paddock, as well as on street tracks, allowing drivers to counter oversteer more effectively.

Rev counter

One other change is as much aural as it is technical. Porsche has introduced a new, four-plate clutch that allows for an increase in rev limit on the start line from 6500 to nearer 8000rpm to reduce the possibility of stalling. Even if a driver does manage to stall the car on a start, the car's rear lights will automatically flash to warn those behind, while a simple press on the clutch pedal will restart the engine.

'The new 911 Cup stands out, thanks to the extensive attention to detail that has gone into its development,' says Matthias Scholz, director of GT racecars at Porsche. 'It is stronger, faster, yet also more practical. Component service life remains unchanged – in some cases even extended – despite the increase in performance.'

Aero driven

The detail behind the upgrade to Porsche's refreshed GT3 car for 2026 belies its appearance

By ANDREW COTTON

Porsche has unveiled its latest GT3 challenger, an Evo update of the existing 992 model. The car is, says Porsche, easier for teams to set up, more predictable for drivers, and therefore more suitable for the paying non-professionals that frequently occupy the space behind the wheel. All this after extensive feedback from customer teams around the world.

While the engine and gearbox remain unchanged from the previous iteration, the manufacturer has also taken the opportunity to add cooling to key components, such as the steering rack and the driveshafts. In the past these items have presented concerns, although Porsche is at pains to note they have not yet contributed to a DNF.

The updated Porsche 911 GT3 R has already tested in race conditions at the 12 Hours of Spa, a contest organised by Dutch promoter, Creventic. It has also been through the Windshear wind tunnel, though the final specification has not yet been ratified by the FIA. Homologation will take place towards the end of this year, ready for racing early in 2026.

The likely debut in customer hands is thought to be the 24 Hours of Daytona in January 2026. The Evo's task is to build on the work carried out by the current 992-generation Porsche 911 GT3 R, which has won the 24 Hours of Le Mans back-to-back in class, as well as titles in the FIA World Endurance Championship, IMSA Sportscar Championship and DTM.

Pitch perfect

Principally, Porsche says it has worked on the aerodynamics of the car, to improve its behaviour on the brakes. The existing model is tricky to drive, as drivers must trail brake into a corner to keep the weight on the nose, which helps rotation, but it's tough to set it up and not easy for a customer driver to achieve the right pitch every time.

'[A customer driver] reaches the apex either the proper way, or the car is too close to the ground, has too much front, and it clings to the inside like hell, and then they have to open the steering earlier,' says Sebastian Golz, project manager for the Porsche 911 GT3 R. 'It means that if they try to take the corner perfectly 10 times, they achieve it maybe five times. Now they will be able to increase that quantity.' Downforce at the front comes from two areas that are independent of each other, namely the splitter and louvres over the front wheels, which help to evacuate the air efficiently.

Development in these areas helps to reduce the car's tendency to dive on the brakes, and squat on acceleration, again to aid stability in cornering. 'With the kinematic change, and the louvres, there is less tendency to have an aero transfer to the front,' continues Golz. 'Kinematic changes keep the platform more stable and, if you suck the air out of the wheelarches, the downforce level is a bit different, as is the percentage of total aero created by the front splitter. This all helps to have less sensitivity on aero balance.'

The new car has an enclosed underbody and is re-inforced at the rear. The multi-link rear suspension is also improved to increase the anti-squat effect that then reduces the rear-end compression under hard acceleration. This, in turn, then improves the load distribution between the axles.

There is a new swan-neck rear wing that is also fitted with a 4mm Gurney flap which broadens the scope for aero balance adjustments by the team.

A new ABS system from Bosch has also been introduced, and Porsche says the test race at Spa provided the results its engineers had hoped for – a more predictable car on the brakes, that's easier to set up for a non-professional driver.

A more predictable car on the brakes, that's easier to set up for a non-professional driver

Cooling off

Work was also needed to improve reliability, and Porsche has done this through an improved air cooling package. When the 992 model was launched ahead of the 2023 season, it had a 48mm longer wheelbase than the previous 991.2 version, with the engine and gearbox pushed forwards and down as low as possible. That meant more angle on the driveshafts, both horizontally and longitudinally. While this was not a problem in normal running, on high-speed circuits such as Daytona and Le Mans, where the car runs low, with high load and for long periods of time, it became an area of concern. 'Last year we added a cooling duct [within] the brake cooling ducts to the driveshafts, but if you started to blank off the rear axle, to increase brake temperature, you also blanked off the driveshafts and that caused an issue,' says Golz. The solution for the 2026 model is to introduce a NACA duct in the floor that works independently of the brake system.

Another area of concern was the steering rack, and its behaviour under high load. With

All photos: Porsche

Porsche tested its 2026 GT3 contender in race conditions at the 12 Hours of Spa in April, finishing second overall

Porsche's Evo update builds on the current 992-generation 911 GT3 R, which has won Le Mans twice in class, as well as multiple championships

the latest generation tyres from each of the manufacturers, a higher-than-expected weight from the BoP, and with teams achieving more grip through set-up, the steering system started to show abnormally high temperatures. That was a worry for the engineers, and led to unexpected feedback for the drivers.

'If you get a loading from the side and the tyre wants to move the steering back, the driver would feel it more than expected. The oil was getting too hot, bubbling a bit and so the efficiency was dropping and the drivers didn't get full support,' explains Golz. An additional fluid cooler was introduced, which brought temperatures into normal range.

Other changes include rear wheel bearings made from ceramics rather than steel to improve rolling resistance and avoid the potential for rust after a wet race. The housing of the differential has also been modified to reduce wear, and the way a driver controls the traction control on the steering wheel has been made more intuitive. Data transfer from the car is now done via a USB stick rather than plugging in a laptop.

Option packs

As is now typical with Porsche motorsport products, there are options for teams to select when buying the car, including a sensor package, endurance package, pit lane package and camera package. These kits include laser ride height sensors, two master brake cylinder potentiometers, a track temperature sensor, rear-view camera and mountings for a water bottle system.

To help teams that race in the WEC, IMSA and the SRO-managed races in which refuelling is required, a refuelling detection sensor registers when the nozzle is inserted and there is an additional refuelling LED light.

Customer teams can also choose from a range of special equipment options that are tailored to the demands of the individual GT3 series around the world in which they might choose to race. These include special driveshafts for the LMGT3 class and IMSA suitable for torque sensors, a special pre-silencer for the NLS and wing supports with a modified adjustment range.

The kit to upgrade a current Porsche 911 GT3 R to Evo specification costs €41,500 plus tax (approx. $48,200). A brand-new 2026-spec car is €573,000 (approx. $665,000).

Porsche started development work on the Evo package in August 2024, the comprehensive test programme including stops at Sebring, Paul Ricard, Spa-Francorchamps and the Nürburgring

The longest month

GT3 racing saw three 24-hour races on successive weekends in June this year. How did the manufacturers cope with the challenge?

By ANDREW COTTON

Due to quirks of scheduling, for the first time, the three biggest 24-hour races of the European season followed each other on successive weekends in June 2025. Each featured GT3 cars, either as the sole category, as the fastest cars on track, or the slowest cars on track, depending on the series.

On paper, it all should have been quite straightforward. In reality, though, it was anything but. The cars may have been the same models – BMW M4 GT3 Evos, Porsche 911 GT3 Rs, Ferrari 296 GT3s and the like – but the different technical and sporting regulations meant the manufacturers represented in each of the three races faced event-specific requirements that were, to put it mildly, challenging.

The first leg of the triple-header was the 24 Hours of Le Mans, which took place on 14-15 June, one week after a compulsory test day at the French track. The race forms part of the FIA World Endurance Championship and is run by the Automobile Club de l'Ouest. It is contested by privateer teams that must, by regulation, use a mixture of professional (pro) and amateur (am) drivers.

Leg two was the Nürburgring 24 Hours in Germany, an event run by the ADAC Nordrhein club. The event is usually tabled around the Ascension Day holiday weekend in May, but this year was linked instead to the country's Corpus Christi festival (*Fronleichnam*) and therefore held on 21-22 June. Driver line ups may be all professional for this race, or a mixture of pro and am. Although it attracts the world's best GT3 pilots, the N24, as it is often referred to, has traditionally been dominated by the big four German car brands: Audi, BMW, Mercedes-AMG and Porsche.

For many years, the N24 was a standalone event, although closely associated with the Nürburgring Langstrecken-Serie (NLS) that also runs on the Nordschleife. Since 2024, it has been a round of the Intercontinental GT Challenge (IGTC), a series linking the biggest races around the world where GT3 cars win outright. The others are the Bathurst 12 Hour, 24 Hours of Spa, Suzuka 1000km and Indianapolis 8 Hour.

Spa is the showpiece of the IGTC. This year, it was also the third and final leg in the string of consecutive 24-hour enduros. In 2023, the event was pushed off its historic date at the

The 24 Hours of Spa is the only one of the three endurance races that features a full grid of GT3 cars

High speed change of direction is a common theme across the three circuits, meaning the emphasis is on aero stability

The cars may have been the same models… but different technical and sporting regulations meant the manufacturers represented in each of the three races faced event-specific requirements

The top speed capability at Le Mans requires longer gearing, which is only otherwise used on the banking at Daytona

end of July by the Belgian Grand Prix. Its organiser, the SRO Motorsports Group, found a new date on the final weekend in June and it now looks to stay there for the foreseeable future. With Le Mans always taking place in mid-June, and the N24 moving each year based on the regional religious calendar, the potential for a triple header was set.

We covered the technical differences between the GT3 cars competing in different championships in *Racecar* V35N7. These include running torque sensors or air restrictors, engine control units that have to be calibrated to different requirements and a variety of performance balancing tools.

Here, with BMW and Ferrari engineers who worked all three races in 2025, we look at the similarities, and the differences, of the European 24-hour classics from a manufacturer perspective, covering the demands of the teams, drivers, grids and circuits.

Same, but different

Firstly, the similarities. Each of the three races was contested with GT3 cars, which are by nature of production origin, with factory-based engines. They are built by manufacturers and sold to customer teams, who are then free to choose in which championships they run.

Making life somewhat easier this year, all three of the 24-hour races took place in dry conditions. The N24 has often been disrupted by poor weather, and fans have long hoped it would move permanently to June to reduce the risk of rain, fog and even snow. Spa is also famous for rain and, as Jason Statham memorably noted in his voiceover for Audi's *Truth in 24*, 'It always rains at Le Mans.'

Few could therefore have predicted that in 2025, Europe would be basking in unseasonably high temperatures for much of June. While that suited the drivers for visibility, and the tyre fitters for workload, it meant there was extra pressure on the cars, which ran flat out in all permitted conditions (save for yellow flags, slow zones and safety cars).

All three tracks feature long straights and high-speed corners. At Le Mans, the section from Tertre Rouge to Mulsanne, and from Mulsanne to Indianapolis offer the highest speeds of the three. These sections align in demand with those of the Nürburgring's Schwedenkreuz, Kesselchen and Döttinger Höhe, while at Spa, the Kemmel Straight and the run from Stavelot to the Bus Stop similarly test the racecars at v-max.

Each circuit also has a series of quick corners, including the Porsche Curves, the Eau Rouge-Raidillon complex and most parts of the 'Ring. Both Spa Francorchamps and the Nürburgring also feature a section of high compression, so load on the suspension can be high and ride height management is deployed accordingly.

Key features of the big three GT3 endurance races

	24H Le Mans	Nürburgring 24H	24H Spa
Organiser	ACO	ADAC Nordrhein	SRO
First held	1923 (GT3 class from 2024)	1970 (GT3 class from 2009)	1924 (GT3 class from 2006)
Series	FIA WEC	IGTC	IGTC, GTWC Europe
Cars	Hypercar, LMP2, GT3	GT4, GT4, TCR among others	GT3 only
Tyres	Goodyear (single spec)	Open choice (multiple specs)	Pirelli (single spec)
Track length	13.626km	25.378km	7.004km
Key features	Driveshaft torque sensors, longer gear ratios, lower ride-height, slow zones / safety car	Air restrictors, shorter gear ratios, raised ride-height, accident control via local speed limit	Air restrictors, shorter gear ratios, ride height set for compressions, FCY / safety car
2025 participants	62 (including 24 GT3s)	134 (26 GT3)	74
2025 pole time	3m 52.789s (210.7km/h)	8m 12.741s (185.4km/h)	2m 15.113s (186.6km/h)
2025 winner	Manthey (Porsche)	Rowe Racing (BMW)	Grasser Racing Team (Lamborghini)

High compression on entry to Eau Rouge at Spa means teams have to compromise on ride height set-up ahead of the 24-hour race to ensure a car can last

The 2025 editions of the big three enduros were all dry and warm, which makes a change, especially in the Eifel and Ardennes mountains

The bumps through Karussell and Kleines Karussell at the Nürburgring are notorious, frequently catching out amateur team drivers

Due to its particularly high-speed nature, Le Mans is the outlier in terms of gear ratios. Manufacturers may homologate up to three sets, though BMW has chosen only two. Short ratios are used for all other circuits, with the exception of Daytona in the US.

Genetic make up

The genetic make up of the circuits is very different. Le Mans is primarily public road, with local drivers using the section between Tertre Rouge and the entry to Porsche Curves on their daily commute. The track surface is therefore low energy, which helps teams extend the life of their tyres, particularly under cooler temperatures at night.

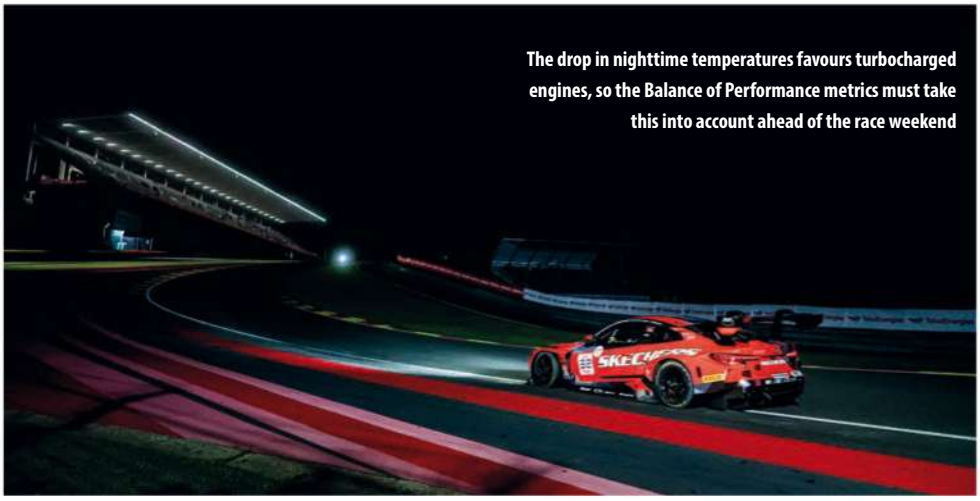
The Nürburgring, meanwhile, is a permanent circuit that is widely used for car testing and public track days, as well as for racing on multiple weekends per year. It is re-paved with new asphalt frequently, but this work tends to focus on specific areas each time due to the track's extreme length.

Spa is an FIA Grade 1 venue and the only one of the three on which Formula 1 cars can race. Consequently, the track surface is abrasive, offering high levels of grip.

Mauro Barbieri

'You can try to play around on the straight, to drag the tyres a bit to generate more face temperature… but it's always a compromise, because you can gain or lose in the first lap or half a lap to warm up'

Mauro Barbieri, head of performance and governance relationships at Ferrari endurance racecars



The drop in nighttime temperatures favours turbocharged engines, so the Balance of Performance metrics must take this into account ahead of the race weekend

Each of the three 24-hour races run to very different technical regulations, and the tyre rules are the first place to start. Goodyear supplies the LMGT3 class at Le Mans with a single specification slick, while Pirelli enjoys a similar spec tyre deal at Spa. Conversely, there is open tyre competition at the Nürburgring with different compounds available, which means tyre strategy only really comes into play there. Michelin, Goodyear, Pirelli, Yokohama and Falken are among the combatants.

'We leave [tyre choice] open to the teams,' confirms Ferrari's endurance racecars head of performance and governance relationships, Mauro Barbieri, of the Nürburgring race. 'They can make their decision based on whatever the driver might want, so cost, or performance, or [driver] ability, but also the fact that maybe one supplier has better slicks, while another one has better wet tyres.'

Then we come to the subject of tyre warmers. They are banned at Le Mans, while the N24 and Spa allow them. This creates further challenges for the manufacturers and their teams as tyre warm-up for a one-hour stint at Spa requires a different approach to the multiple stints teams aim for at Le Mans.

'You can try to play around on the straight, to drag the tyres a bit to generate more face temperature,' says Barbieri of the shorter stints. 'You can run a bit stiffer all round to have the tyre move more, squeezing a bit more on the shoulder. This is also a way to generate temperature, but it's always a compromise, because you can gain or lose in the first lap or half a lap to warm up. For example, at Le Mans, you have to do three stints, and you cannot just focus your set-up on the first three corners as you have to do 45 more laps, and the car needs to be balanced.'

Suspension and aero

Moving on from tyres, the next area to focus on is suspension, which is closely linked to aerodynamics. Again, there are very different rules here for teams competing in the different series, while the dissimilar track layouts place unique demands on the cars.

'Basically, everything begins from the suspension,' says BMW electronic software and systems engineer, Simon Schneider. 'So, from ABS to the traction control. You also have different aerodynamic configurations, so the platform has to be different as you have different ride heights you are allowed to run. At the Nürburgring we have a different minimum ride height to Le Mans and Spa. We normally go a bit higher [than the minimum] at Spa because of the big compressions, but you have three levels – Le Mans, Spa and Nürburgring – and have to adapt everything.'

At Le Mans, the high speeds and low kerbs encourage lower ride heights, but there is lap time to be gained by clipping the particularly high sausage kerbs through the final chicane.

Setting the car up for Bronze category drivers is a key focus for teams competing in the FIA World Endurance Championship, as each crew must contain at least one non-professional driver

'It's always a game,' says Schneider. 'Do you gain performance if you take them, or do you gain performance if you go a bit lower and avoid them?'

Driver training

The regulations for what category of driver may be behind the wheel in the various series affects set-up, too. A WEC driver line up, for example, will run a Bronze category driver as a compulsory element of the team, while the IGTC and GT World Challenge permit all-professional line ups. 'Generally, the car is softer and a bit lazier,' says Barbieri of the WEC car featuring a non-professional driver. 'It has more understeer dialled in, and is a bit smoother, more progressive, less snappy. You are looking for a different balance, so the amateur driver feels more confident. The pro will just drive around these characteristics.'

'In Le Mans, you need to have a car suitable for your Bronze driver, for your Silver and for your pro driver,' adds Schneider. 'The car needs to be less pointy and more forgiving.

Simon Schneider

'You have to set the car up so it is comfortable and safe for your Bronze driver, yet still fast enough to perform with the pro driver in it'

Simon Schneider, electronic software and systems engineer at BMW

The multi-class racing at Le Mans, in particular, makes a big difference in terms of strategy and pit stop sequences

For sure, if you go on pure performance and put in three pro drivers you would set it up differently and they could handle it, but this is the trade-off. You have to set the car up so it is comfortable and safe for your Bronze driver, yet still fast enough to perform with the pro driver in it.'

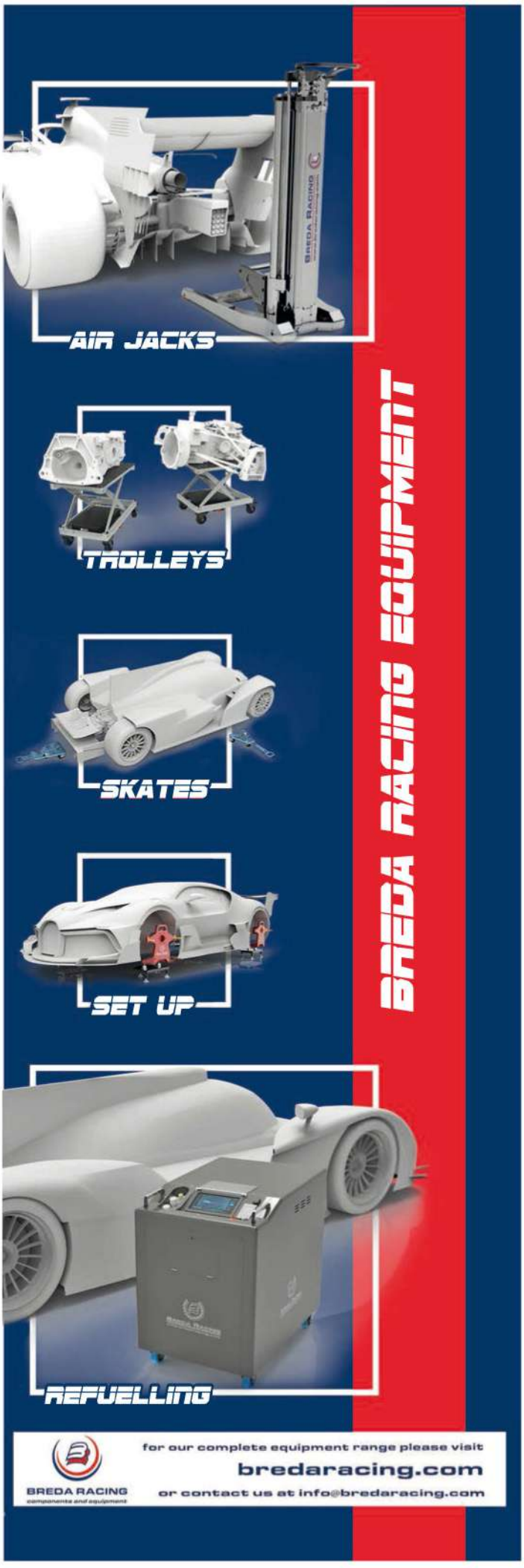
Further complexity comes from the sporting regulations, which also differ between the three races. For example, the various organisations manage accident zones very differently. That leads to a change in electronic control for the individual races, which means divergent strategy options for the teams.

Le Mans uses slow zones to moderate the speed of cars past the scene of an accident, to prevent using the safety car wherever possible. At the Nürburgring, the safety car is only used in specific scenarios such as poor weather, while major accidents are covered by Code 60 or 80, a speed limit past the location of the incident. At Spa, however, the shorter track allows for a Full Course Yellow situation to slow all cars on track to the same speed, before the safety car is deployed.

'It's completely different because you have the slow zones and you have the safety car,' confirms Schneider. 'Based on the system, [WEC race direction] controls the speed of the cars with their safety car, or the Full Course Yellow using their scrutineering logger. At Spa, at least it's the same as at the Nordschleife because you just rely on your speed. You get nothing from the officials, you just do your 80km/h, or 60km/h.'

'Most of the electronic parameters can only be adjusted by Ferrari,' adds Barbieri. 'This is one of the reasons why we have people on track, because if the crew, or the race engineer, needs something adjusted, we're there to do it.'

That does not mean Ferrari is responsible for the legality of a car. That responsibility still rests with the team, which has a duty to ensure its car is compliant in all scenarios.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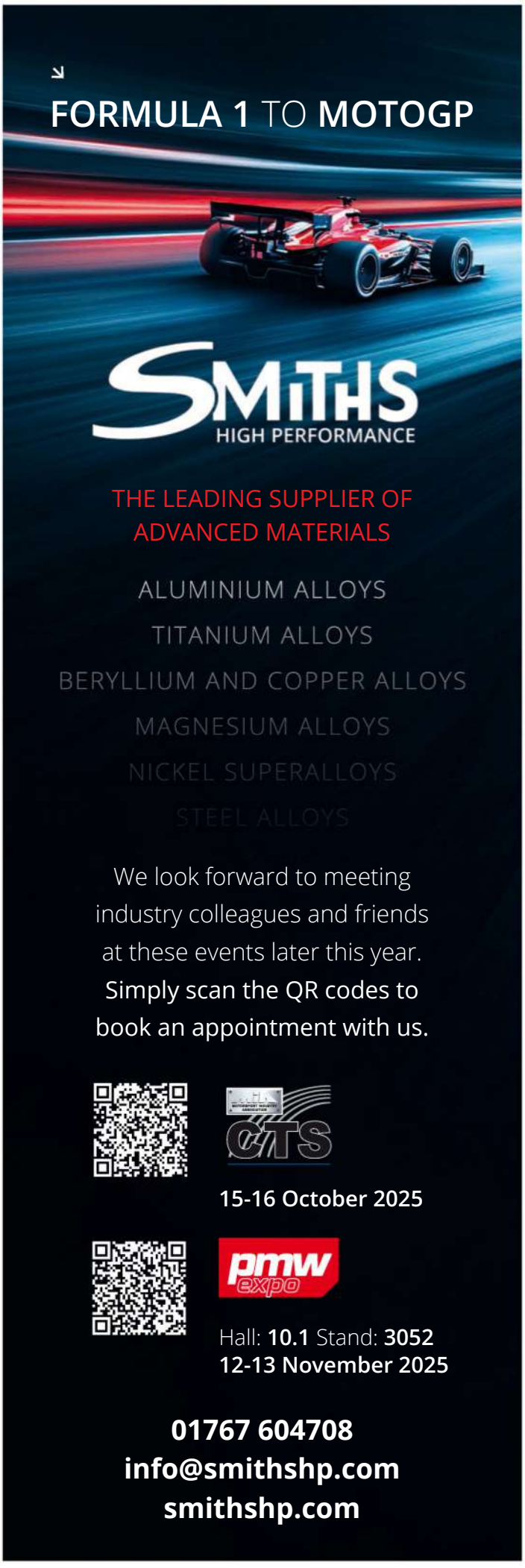
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Even the length of the track makes a difference to how a car is set up, along with the number of cars entered for each race. Le Mans is 13.6km and starts 62 cars, including a mixture of GT3, Hypercar and LMP2. By comparison, the Nürburgring is around 25km and allows more than 140 cars to take the start, with GT3 cars being the fastest in a class called SP9. Since 2020, only GT3 cars have raced at Spa and 74 took the green flag on the 7km track for the 2025 edition, the various classes separated only by the combination of driver grading.

Those figures equate to one car every 219m at Le Mans, one every 177m at the Nürburgring and one every 94m at Spa. The Belgian track, therefore, sees more pack racing, which explains why Lamborghini has designed its new Temerario GT3 racer to better cope in traffic. Ferrari has done similar with its 296 GT3 Evo.

Balance of Performance

Each of the series runs its own Balance of Performance system. We have covered this in detail in previous articles on the subject but, assuming the BoP is accurate in each race, the different grids change the shape of competition significantly.

'The field is quite level in terms of performance so, even if you end up behind some slower drivers – say, Silver or Bronze category – it still might be difficult to overtake and you may lose some time in the process,' says Barbieri. 'Then you are also going to make decisions about pitting or not behind the safety car and making sure you don't end up behind slower cars.

'This was also the case when we were there with pro cars, trying to make sure you don't fall behind an am, because then you would lose time. [Where you have] cars with different strengths and weaknesses, you might be stuck behind a slower car in the corner, but then cannot overtake because on the straight it has more power than you. For sure, that plays a role and it adds complication, not only on the strategy side, but also driver and car set-up.'

The difference [in fuels] means even more development work has to be done with the engine mapping software to ensure the cars run as close as possible to the power level permitted by the BoP of each event

One other area in which the teams must be mindful is fuel. The WEC and GT World Challenge use biofuel from TotalEnergies, while at the Nürburgring teams use regular pump fuel. The difference means even more development work has to be done with the engine mapping software to ensure the cars run as close as possible to the power level permitted by the BoP of each event.

'At the Nordschleife, you have the normal petrol station fuel, and in GT World Challenge and the WEC you have the same fuels, but in the WEC you have torque sensors, so you need to adapt all your mappings, and also adapt all the systems in the car to stick to what you have through the torque sensors,' says Schneider. 'Basically, I think all the manufacturers did it the same way, the P0 power level is designed so they can achieve this power level in any circumstances. So with quite hot conditions, with dirty air, with bad fuel. You normally have enough margin to cover all these things, and always run on the [power] level. But when you have restrictors [performance can vary], especially depending on outside temperature, then it can happen that the power is going up and down.'

In the GT World Challenge 24 Hours of Spa, Ferrari had to support both its works teams and the privateers who made up the majority of the 74-car grid

Manufacturer support

From a manufacturer perspective, successfully managing the three longest races of the year on successive weekends requires having an intimate knowledge of all the different regulations, tracks and the teams and drivers competing, and then working out how to best support them all.

Ferrari split its responsibilities between its technical staff, allowing some to come to the front at two of the three races, but then take a more supporting role at the third. This strategy meant engineers could get some much-needed rest between rounds.

Not so for Barbieri, however, who attended all three for Ferrari, meaning sleep deprivation was an additional concern. 'I attended the GT World Challenge at Monza after doing three WEC races in a row, and it was a completely different event,' says the Italian. 'I asked people to remind me, how does it work with the tyres? Can we double stint them? No. Can you make a difference in the pit stops? No, there is a minimum time on pit road. Okay, so can you save fuel and go longer? No, because there is a maximum stint length in terms of time.

'So, every time you go into a different championship, you need to refresh yourself. We normally try to do some slides to record the main points of the championship at the beginning of the season, so every time we go to a different championship, we can refresh ourselves using those.'

Added IMSA

Just to add to the complications, the IMSA Sportscar Championship also had a race on the same weekend as the N24, which then put even more pressure on the manufacturers to support their teams with a limited number of drivers. For example, BMW chose to only have one all-professional driver line up at the Nürburgring as so many of its drivers were also competing in IMSA.

It's clear that having so many major races packed into such a short space of time meant logistical and technical headaches for teams and the manufacturers. While three races with ostensibly the same cars on similar circuits may sound manageable from the outside, the reality is that each race has its own challenges that require very different handling.

Mercifully, it will be a few years before the stars align in a similar fashion again so Le Mans, the Nürburgring and Spa all host major 24-hour races in the same month. At least next time the teams will know even better what to expect.

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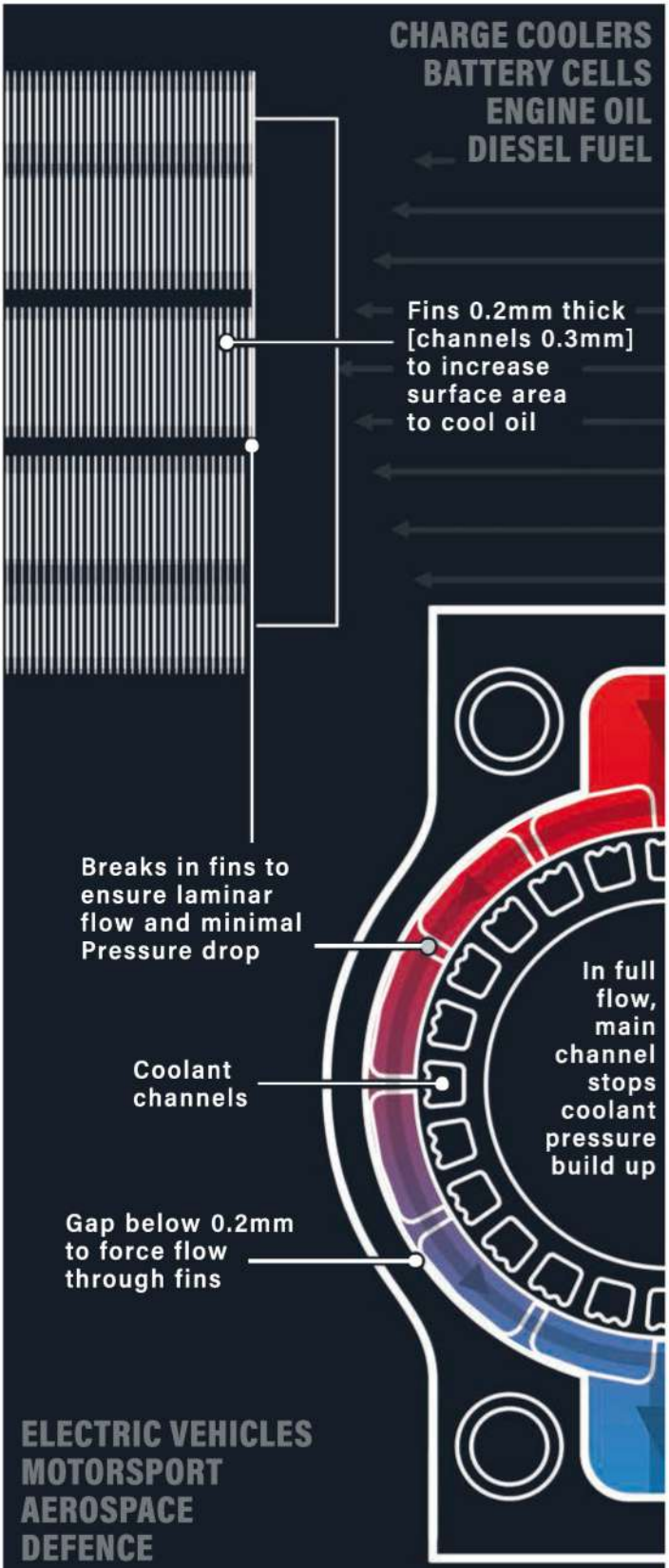
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Coming to the 4

Diving into the development of the Gen4 regulations, which promise to deliver the fastest Formula E car to date

By DANIEL LLOYD

Dan Ticktum's eyes lit up when asked about the next generation of Formula E cars during a press conference at the 2025 London E-Prix. 'Power' was the British driver's straight response, delivered with a grin. Reigning FIA Formula E world champion, Oliver Rowland, then added to his competitor's viewpoint, declaring, 'It's going to be a beast.'

The Gen4 technical regulations, published in June 2025, promise a higher power output, permanent four-wheel drive, more front axle regeneration and more downforce. This has given the existing crop of drivers something to look forward to when the new vehicles debut in the 2026-'27 season, as their reactions in London suggested.

'The simulations and speed trace numbers I've seen, it's going to be a proper racing car,' continued Rowland. 'The pace will be arguably quicker than F2. If you look at the G-Long traces of the car and how it sustains it down the straight, they're going to be extremely fast. Formula E and the FIA maybe need to think about which tracks we go to and how we manage the power on certain tracks but, from Formula E's perspective, it will really put us on the map.'

Gen4 is set to mark another step change in Formula E car technology, which has come a long way since the inaugural season in 2014-'15

The basics

The basic facts of Formula E's Gen4 car have been known for over a year now, but many of the interconnecting details were unofficial, until the FIA's recent publication of the regulations in their first guise.

The Formula E record at Monaco is seven seconds slower than its F2 equivalent, but the more powerful Gen4 cars in high-downforce trim are expected to eat into that deficit

Formula E introduced its Gen3 car in 2022-'23 and updated it with the Gen3 Evo in 2024-'25. The next generation is set to be even faster, with more power and a higher level of downforce

The car will feature a maximum power output of 600kW (up from 350kW in today's Gen3 Evo). Currently, that maximum power level and four-wheel drive are only available in qualifying duels, during race starts and when Attack Mode is deployed. However, with the Gen4, they can be utilised all the time.

The new car will regenerate up to 700kW from the braking systems at both ends, an increase of 100kW. There will be two different aero configurations, up from one, and a change of tyres, Bridgestone replacing Hankook as series supplier. All in, Gen4 is set to mark another step change in Formula E car technology, which has come a long way since the inaugural season in 2014-'15.

Through generations

The championship's Gen1 era was characterised by cars that produced 200kW from a rear-mounted spec electric motor. Because the battery couldn't last a full race distance, drivers had to swap to a second car halfway through. As there was no prior reference point for electric single-seater racecars, chassis design was kept close to that of a contemporary open wheeler, with a traditional carbon monocoque. The battery was then bolted into the rear of the car, roughly where the fuel tank would be installed for an ICE powertrain.

The more advanced Gen2, which made its debut in 2018, increased power slightly to 250kW. The higher capacity battery (which removed the need for car swap pit stops) was fitted from underneath in a carbon fibre housing that reduced weight and lowered the car's c of g considerably.

This architecture was kept for the more powerful again (350kW) Gen3 car, although this time battery capacity was reduced to improve the car's dynamics, as part of a 44kg overall weight saving. Major architectural changes were made on the front end as four-wheel drive was incorporated for occasional usage. For instance, instead of having torsion bars running through the nose, a coilover suspension system was developed to accommodate the newly installed front powertrain, known as the FPK.

'Gen4, I would say, is an additional evolution from Gen3 because we also have an FPK and the battery architecture at the rear is similar'

Pierre Prunin, motorsport director at Spark Racing Technology

'Gen4, I would say, is an additional evolution from Gen3 because we also have an FPK and the battery architecture at the rear is similar,' says Pierre Prunin, motorsport director at Spark Racing Technology, the French company that has built all Formula E chassis to date.

The packaging of the Gen4 front powertrain has proven to be a challenge for Spark, as the architecture of the system is bulkier, more like a rear powertrain layout. The Gen3 has the motor and inverter grouped in a single block with an epicyclal drivetrain, whereas in the Gen4 they are less tightly knit.

This integration challenge was solved by increasing the size of the nose. Furthermore, the opening to extract the FPK from its housing wasn't large enough, so Spark incorporated what Prunin describes as a 'novelty', an additional opening that will give the Gen4 a unique look among single seaters.

While Spark oversees the front powertrain in Gen3 (using a Lucid Motors MGU), that role has been transferred to Marelli for Gen4. The Italian company has so far been tight lipped about the specifics of its 250kW system.

Design priorities

Each Formula E car to date has been different from the last, to the point that if you asked 50 people to draw one, you would probably get a wider range of responses than if you asked those same people for an F1 sketch. While the Gen1 vehicles resembled standard single seaters, Gen2 introduced a design akin to what you might find in a child's Hot Wheels box. Gen3 marked another departure, removing the Gen2's wheel covers, reducing the overall size and going for a more angular look. The new breed is again set to be visually different, although more in line with current single seaters on the F1 ladder, especially in terms of the rear end, which is set to incorporate a new wing.

'Coming to the fourth generation, we were not starting from scratch,' says Pablo Martino, head of Formula E at the FIA. 'We had some learning processes from Gen1 to Gen3 that had been accumulated. The Gen4 concept was created even when the Gen3 car was in the development process; we were already thinking six years ahead.'

Although Formula E has done well to complete its first decade (how many new series in this century have managed that?) it knows where it stands in global motorsport.

'We have seen Formula E moving from tiny, twisty street circuits to more [conventional] circuits… [and] we are taking another step in performance with Gen4'

Pablo Martino, head of Formula E at the FIA

It considers itself the pinnacle of electric racing, but still has some catching up to do in terms of being as popular and lucrative as F1. Making the cars faster is viewed internally as a way of closing the gap.

'We have seen Formula E moving from tiny, twisty street circuits to more [conventional] circuits,' says Martino. 'That makes the championship more credible in a motorsport that is still driven for petrolheads. With the Gen3 car, we have shown that we can perform at circuits that, in the beginning of the championship, were impossible, such as the full Monaco circuit. We are taking another step in performance with Gen4. We are confident on the outcome of this new generation because it's going to put Formula E in a really strong position in motorsport.'

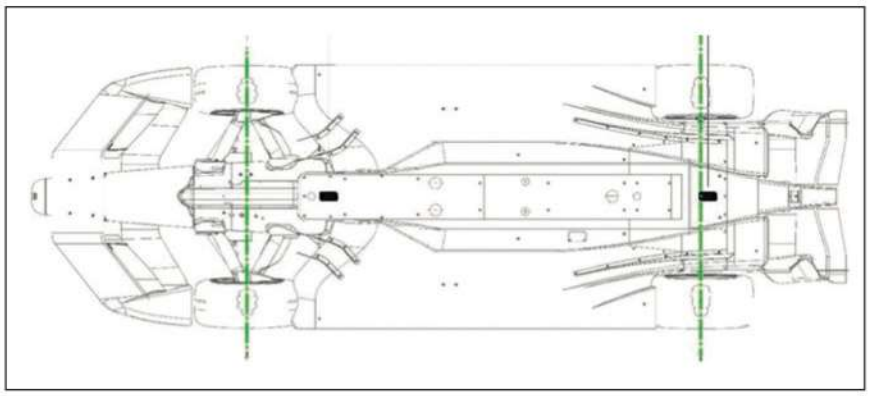
Multiple figures in the paddock have mentioned FIA Formula 2 when speaking about Gen4. It is not an official target to match F2 lap times, but that is what the simulations are currently saying might be possible. The only reference track where both categories race is Monaco. The F2 qualifying lap record there is 1m 19.309s (by Charles Leclerc in 2017) while the Gen3 Evo lap record is a 1m 26.315s set by Taylor Barnard this year. That gives an idea of the gains Formula E is trying to achieve with its next generation.

Performance target

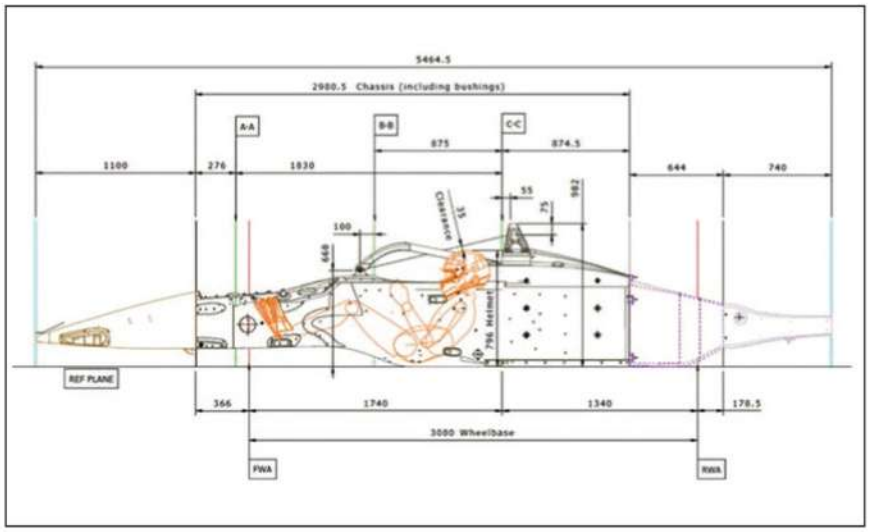
'Since day one, we have said that now is the time to show the performance of Formula E for lap time,' says Vincent Gaillardot, Formula E technical manager at the FIA. 'What should we take on board to achieve such an objective? Power is one of the main things. Having permanent four-wheel drive is another. We always try to stick with the big OEMs' roadmaps, and four-wheel drive is starting to be on more mass production cars.'

According to Gaillardot, battery and cell development have facilitated the increase in power that is recuperated under regeneration. A higher capacity battery with a new cell design from new supplier Podium Advanced Technologies, storing about 55kWh of electrical energy, was needed to facilitate increased consumption from the twin MGUs. The rear powertrain, meanwhile, producing up to 350kW, remains open to manufacturer development. This has been further opened to the competitors with the implementation of active front and rear differentials with a single hydraulic or electrical locking device, which manufacturers can design.

Gaillardot reckons the 'peloton' style of energy-management racing could continue into Gen4, while the increased acceleration capability of the new cars might aid overtaking



Regulatory sketch of the Gen 4 car's underfloor. The new generation racers are set to resemble more closely an F1-style single seater, after two generations of highly distinctive machinery



Survival cell dimensions for Gen4, as published in the first version of the technical regulations. Upgrades to the front impact structure to meet the FIA's F1-standard energy absorption tests have contributed to an increase in car length

Another priority was to increase downforce, improving on a weak area of the Gen3 Evo car. Unlike its predecessors, the Gen4 will be characterised by two distinct aerodynamic profiles. One is a high-downforce configuration, aimed at maximising speed through the corners and delivering championship-record lap times. The other is a low-downforce or, more accurately, low-drag configuration that will be closer in performance to the Gen3 Evo.

Conversion kits

Readers who followed the hybrid LMP1 sportscar era might remember the days when manufacturers would build different downforce configurations and choose to deploy them at certain tracks; this practice disappeared with the advent of Hypercar. Although its plans are provisional, Formula E is not intending to govern the use of its aerodynamic configurations in the same way. Currently, the plan is to use the high-downforce kit in qualifying to show the Gen4 car at its fastest, before reverting to the low-drag kit for races. This means teams will use both aero kits on every weekend, regardless of circuit profile. Under FIA guidance, Spark has tried to limit the number of parts that need modifying, and to make additional parts such as bargeboards and high-downforce wings easy to bolt on and off. Prunin reckons a team of mechanics could do the conversion in about 15 minutes.

'A key objective was performance over one lap,' says Gaillardot. 'We have the power, we have the four-wheel drive. Adding downforce over one lap, even if the drag is higher, is not an issue. Where we have challenges, is we need to have a low-drag configuration for the race, to have the [appropriate] distance as part of the electric vehicle challenge. This is where the two aero configurations come from.'

It is unclear precisely what the delta will be between the two aero set ups, though the original downforce target was 2SCz in low drag and 3SCz in high downforce, while the drag target was 0.65SCx in the former and 0.7SCx in the latter.

Unlike its predecessors, the Gen4 car will be characterised by two distinct aerodynamic profiles

'How we see the evolution between high and low downforce is that the weekends will start with Free Practice in low downforce, with a hard stop to change to high downforce,' continues Martino. '[This is to] not have both configurations on track [at the same time], because it creates a big speed delta. Especially if we are applying extra power, like we do for the qualifying duels. It would represent the potential for cars at 600kW with extra high downforce, against cars at 450kW with low downforce.'

Sized for safety

After a downsizing from Gen2 to Gen3, the Gen4 car is set to go the other way. It will be 520mm (about 10 per cent) longer and 93mm (5.5 per cent) wider, with a longer permitted wheelbase, up from 2960-2980mm to 3070-3090mm. The car will remain at 1025mm in height.

Its size increase has contributed to it being heavier than the Gen3 Evo, which tips the scales at 863kg (including driver). The final minimum weight for the Gen4 car is 'TBC' in the first version of the technical regulations, but something closer to 1000kg appears likely. The car's elongation and increase in cockpit size are the result of enhanced safety measures based on stricter requirements.

'We applied the latest crash standard, which is being increased time after time,' explains Gaillardot. 'This made the car longer because the front impact structure is different. The energy we have to absorb [has increased]. It's a normal job for the FIA, but it has consequences on car design.'

Other safety-related features include the implementation of power steering. This was in response to hand injuries suffered by Robin Frijns and Sam Bird in the Gen3 car, when their steering wheels rotated wildly in what initially appeared to be innocuous incidents. An intermediate fix was rolled out on the Gen3 Evo, whereby a damper was installed on the steering rack to soften the energy passing through when a certain threshold was reached. This, in turn, reduced the velocity of the steering wheel's rotation by up to 40 per cent.

The Gen4 monocoque is made with T1100-grade carbon fibre, while Zylon intrusion panels help to absorb energy from side impacts. The front impact structure was developed by Dallara and Spark.

Circuit specific

As the cars are becoming quicker, this raises the question of whether Formula E's temporary circuits need to be updated from a safety perspective. It is something the championship has been evaluating over the last six months. Although it has visited an increasing number of permanent tracks in recent years, such as Shanghai International

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Circuit, Homestead-Miami and Autódromo Hermanos Rodríguez, Formula E still retains some of the city centre venues that have been at the core of its identity, namely bringing electric motorsport to the masses.

'The safety standards of the current Formula E circuits are up to the level that would be required for Gen4,' says Martino. 'There are just a few adjustments that need to be done to run-off areas and barriers because the top speed approaching the corners will be higher. But it doesn't put a fundamental red flag on any of the current circuits. On top of that, we can play with the power. With that flexibility, we can determine some compromises at specific circuits, or under certain circumstances, if necessary.'

Racing spectacle

The FIA and Formula E have also been looking at ways of making the Gen4 car more adaptable to different tracks. The permanent circuits typically demand a higher energy consumption rate, while the lower demand city courses tend to have more frequent, harsher braking zones for regen' to occur. One idea is to have more power on tap for higher consumption tracks, allowing drivers to push harder for a more exciting racing spectacle.

'We are considering having different ranges of power at races,' confirms Martino. 'Today, we have 300kW Race Mode and 350kW Attack Mode. We are considering keeping that difference between modes, but working with the race power to better adapt the car to [different] circuits.'

'We have now moved to two different sets of tyres. One is still all-weather, but for dry conditions with very small grooves, and one is a proper wet tyre… This is a big part of the performance improvement'

Vincent Gaillardot, Formula E technical manager at the FIA

The Gen4 car has already been on track. Working with the other suppliers, Spark built a mule car that has been testing iterations of the spec components since the spring of 2025. At time of writing, in late July, the mule had done 16 test days, covering 4000km.

'We have tested mainly in the south of Europe, in Spain and Italy,' confirms Gaillardot. 'We classify tracks in terms of energy consumption level. High energy, which is high speed [Monteblanco and Jarama], medium energy [Calafat] and low energy [Varano].'

Dynamometer, four-post rig and wind tunnel tests were all carried out ahead of the track test programme. Some drivers have also experienced Gen4-type settings in the simulator, although there are limitations.

'At the moment, you just increase the grip,' says Lola Yamaha Abt driver, Lucas di Grassi. 'We don't change the width or elasticity, because we don't have a model of the tyre. So we just increase the grip, power and other metrics, and see how the car behaves.'

Tyre development

The tyre is also currently being developed, and Bridgestone is not yet ready to divulge technical details. However, it is known that they will be 30mm wider at the front and 15mm wider at the rear, with larger diameters, too. Currently, Hankook supplies a single all-weather specification, but the increased grip demands from Gen4 will change that.

'Everybody agreed that the single polyvalent all-weather tyre is now over because you can't increase grip [further],' says Gaillardot. 'We have now moved to two different specs of tyres. One is still all-weather, but for dry conditions with very small grooves, and one is a proper wet tyre. We decided the grip increase we wanted to see with the manufacturers. This is a big part of the performance improvement.'

Why does Formula E continue to shun the full slicks used in other high-profile single-seater championships? 'It is a sustainability topic, to have as few possible tyres available,' suggests Gaillardot. 'I do not say that we will not go [full slick] in the future. But step by step.

According to chassis manufacturer Spark Racing Technology, the low-drag aero kit that will be used in Gen4 races generates similar levels of downforce to the current Gen3 Evo, but more performance will be unlocked with the addition of a bolt-on high-downforce kit. Swapping between the two is said to take a team of mechanics around 15 minutes

In racing, we have the crossover point in terms of tyre usage [from one compound to another]. If you have slicks and just a full wet tyre, you do not have crossover. This is why, today, we still have grooves, although they will be smaller. This is to make sure we can race in any track conditions.'

Delivery date

Spark is projected to deliver the first chassis in September, one per manufacturer. They will then integrate their own rear powertrains, sensors and software before heading for a group test where representatives from the spec suppliers, and the FIA, will be on hand to troubleshoot any teething issues. That test is due to take place in early November.

'It works in two ways,' says Martino. 'The suppliers can provide the necessary support to the manufacturers, but the feedback given to the suppliers multiplies a lot, because the mileage increases.'

While the teams will join the track test programme at a certain date, they have already been working in the background.

'We are always updated by the FIA after each test, with parameters like downforce windows, tyre grip data and so on,' notes Florian Modlinger, factory motorsport director for Formula E at Porsche. 'We feed this into our own simulations and draw conclusions for our own development.'

Final generation?

Formula E has used the 'Gen' prefix to delineate its regulatory eras since the beginning. However, that approach might become redundant as the championship evolves. Each of its previous technical generations made significant strides, as electric racecar technology was still in its infancy and the potential gains were huge. But as Formula E matures (it will be a teenager in 2027), the rate of improvement can be expected to slow down.

'We will try to see how to manage the generation concept,' says Gaillardot. 'Maybe [we] try to move away from this four-year cycle. It was needed at one stage due to the technology [making] some big steps. I think the platform we have now with Gen4 should allow us to [operate] in a more flexible way.'

What this means is that future changes to the Formula E technical regulations might not be as drastic. It brings into question whether there will be a Gen5 after Gen4. Or, if there is, whether it might not be rolled out as quickly as previous generations have been. The current car is designed to be a good starting point for something that can be gradually updated over time, rather than overhauled.

'[The thinking is that] we don't need to change massively the technical rules, but only single supply components, or to allow different things on the manufacturer perimeters,' adds Gaillardot. 'We will try to implement things in a progressive way.'

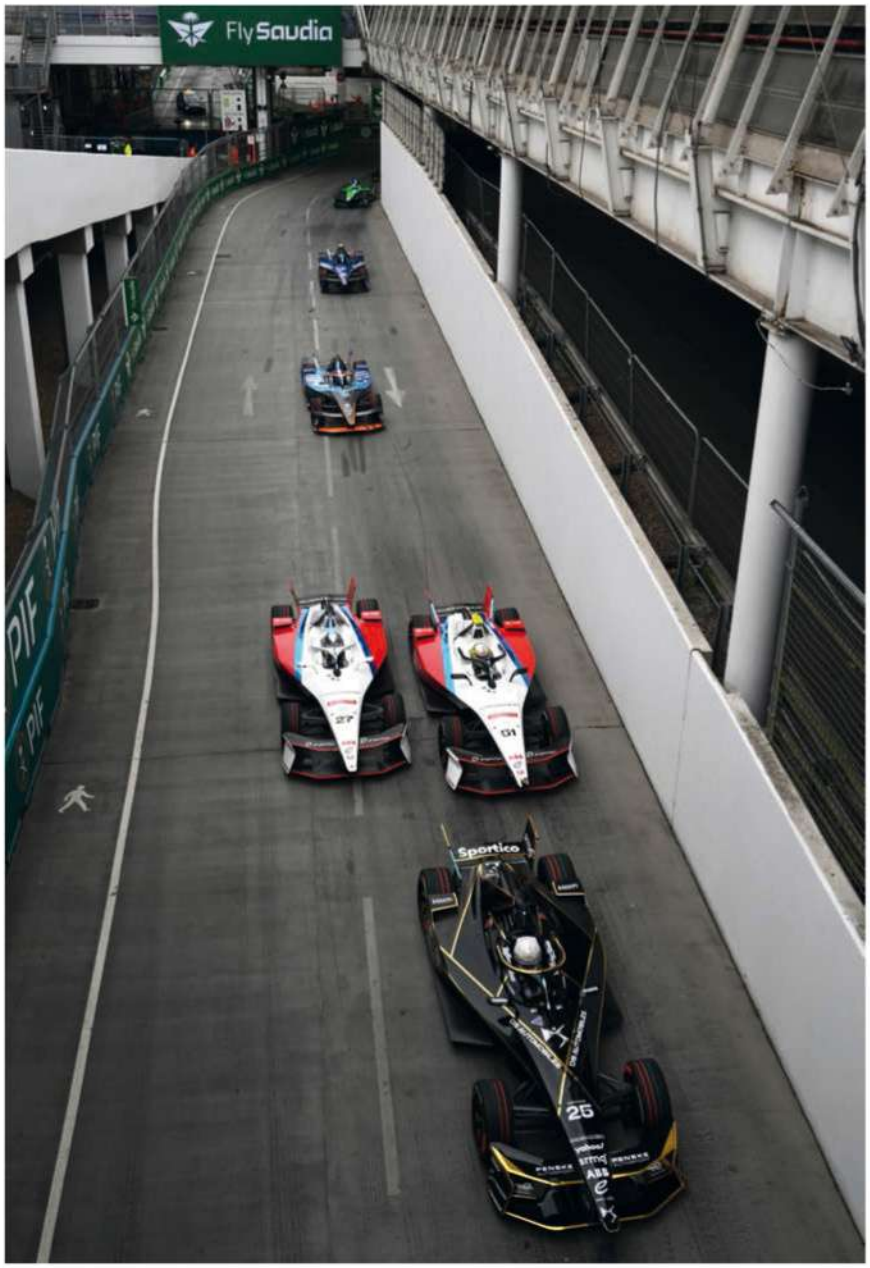
Formula E is here to stay, with Gen4 providing the foundation for technological developments to come

Although Gen4 is still over a year away from its first race, the rule makers and the electric road car manufacturers are already starting to consider what might lie beyond. Understanding Formula E's technical road map is key to enabling manufacturers to decide whether they want to stay, join or leave the series. One overarching topic is the amount of design freedom manufacturers will have. For instance, could battery development one day be put in their hands, rather than those of a single supplier?

'We need to set up the objectives all together, and how we want the evolution to take form,' says Gaillardot. 'There are different topics on the table of what manufacturer perimeters can be opened up more. The battery could be one of them, as well as the FPK. It's part of the road map we are reviewing with them.

'For the OEMs, it's a question of balance [between] the value of return on investment vs cost. This is under discussion. Nothing is closed, but nothing is decided.'

At the 2025 London E-Prix, the FIA and Formula E Holdings announced an extension of their agreement to co-run the championship until at least 2048. The clear message was that Formula E is here to stay, with Gen4 providing the foundation for technological developments to come.



The traditional city tracks that Formula E has been built on shouldn't be ousted by the more potent Gen4 cars, the FIA saying only minor circuit modifications will be needed, and that car power levels can be adjusted if necessary

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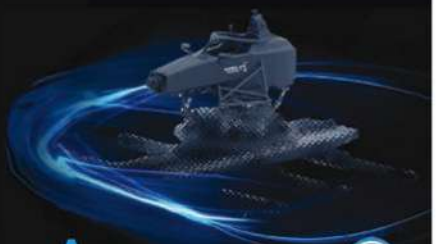

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Protect and preserve

By MIKE BRESLIN

How Motorsport UK strives to strike a balance between ensuring the sport is safe and relevant, while at the same time keeping costs reasonable for competitors

Balance is important in motorsport. Whether that's the aero balance along a racecar, the delicate balance on the throttle when a car is on the limit of adhesion or balancing the books. There's another balance continually at play, though, that many will not be aware of, and that's the calculations the national governing bodies have to make when it comes to setting regulations. The balance part comes in not pricing competitors out of the sport.

The organisation responsible for these calculations in Britain has been known as Motorsport UK since a rebranding in 2018. It was previously the Motor Sport Association (MSA) and, before that, the RAC Motor Sports Association (RACMSA). For the past five years, it's been based at Bicester Motion, the vibrant historic automotive and motorsport engineering hub that's located in the heart of Motorsport Valley.

Its HQ is an interesting place in its own right, with memorabilia such as the fascinating exhibition of helmets belonging to British motorsport greats in the foyer, some impressive racing-inspired artworks on the walls and even a simulator suite for esports.

Motorsport UK represents over 600 motor clubs and 70,000 licence holders across a huge array of disciplines, from karting and Autosolo to rallying and professional-level singles seaters, and everything in between. And there's a lot in between. Competitors make a staggering 120,000 entries a year, for some 3930 Motorsport UK-sanctioned events, which is an average of 10 every day.

Safety first

Motorsport UK is involved in every aspect of motorsport governance, including framing general regulations and sporting rules, but its most important work is overseeing safety. This is ongoing for, as most agree, motorsport will probably never be *entirely* safe, and one of Motorsport UK's most recent safety initiatives is to do with the use of Impact Data Recorders (IDR). This rather neatly illustrates that balancing act between setting regulations and not overly increasing the financial burden on the competitors.

IDRs are common in top-level, FIA-run series, in the form of Accident Data Recorders (ADR) but, at around £1000 to buy, they are not ideal for grass roots motorsport. IDRs, on the other hand, are much cheaper, and have recently become mandatory for cars in some high-level British championships, as well as in junior series, with a roll out to most higher-speed disciplines a possibility in the future.

'The Impact Data Recorder is basically a small, lightweight, self-contained device designed to capture and log data during motorsport crashes and high impact events,' explains Dan Carter, head of safety at Motorsport UK. 'It was developed in collaboration with the FIA and is a low cost, fit-and-forget tool that can be mounted to any competition vehicle.'

An IDR gives a similar level of data as an ADR but costs just £50 and has a two-year lifespan. Unlike an ADR, It's also very easy to install in any competition car.

'It's 6cm long and weighs about 12g. It requires no cabling, no tools, no maintenance. It just sticks into the vehicle,' says Carter.

Motorsport UK is responsible for many disciplines in the UK, from professional categories such as Formula 4 (shown), to entry level 'Streetcar' initiatives such as Autosolo

'The battery is capable of logging over 80 impacts during its lifetime, and it's continuously monitoring the accelerations of the vehicle via low-power Bluetooth [BLE], so it *always* captures the impact. It's a very smart device.'

These IDRs, which were initially trialled in the British Touring Car Championship and other series, are built by Impact Detect and are basically accelerometers, measuring the forces in every direction during crashes and secondary impacts. Also, in contrast to the ADR, they do not require specialist skills when it comes to downloading the data.

'We have a mobile application on both Android and iPhone,' continues Carter, 'and we can give that app to our scrutineers. They can take the 'phone and download the data wirelessly via Bluetooth [using a QR code]. That captures the data, sending it into the cloud. They can also upload driver and vehicle details, and photos, so it creates this holistic crash database for us.'

In the long run, this could also prove to be an indirect cost-saving device, as presently the life of some safety equipment, such as seat belts, is time limited, so they need to be replaced after a set number of years.

'It's really early days, but there have been discussions about if we could have the IDR fitted to all vehicles, could we then determine that if a vehicle throughout its life hasn't had any impacts, could the safety equipment life potentially be extended?

'Or, if there was a heavy impact, does that give us an indication that, actually, safety equipment *does* need to be replaced?'

This approach might be applied to individual pieces of equipment such as seats, but could extend to driver kit. 'We've been in dialogue with the FIA and the manufacturer of the IDR to see whether we could roll out the same, or similar, technology that could be fitted to a helmet, for example,' says Carter.

'[The IDR] battery is capable of logging over 80 impacts during its lifetime, and it's continuously monitoring the accelerations of the vehicle... It's a very smart device'

Dan Carter, head of safety at Motorsport UK

'We wouldn't retrospectively fit it, but the manufacturers could fit it during the manufacturing process.'

Spending cuts

While this would be an obvious way to help competitors cut their spending, there's an argument that *all* safety improvements undertaken by Motorsport UK help reduce costs. For instance, making frontal head restraints (FHRs), such as HANS devices, compulsory initially faced some resistance – largely because they retail at around £200 to £300 – yet these have subsequently proved to be remarkably successful from a safety standpoint, and have also helped reduce costs in an interesting way.

'It's those significant steps that keep the cost of insuring people to go and do what they want to do down,' says Ian Smith, technical director at Motorsport UK. 'So, over the lifetime of your FHR, we're probably saving you money. Part of the journey to mandating the FHR will have been to engage with the insurer to say, this is the data, this is the safety improvement that it will make, this is how it reduces risk, and that in turn brings insurance costs down.'

Motorsport UK's plush headquarters is located right in the heart of Motorsport Valley at Bicester Motion, the automotive, classic car and motorsport hub

There's a suite of professional-level simulators inside the Motorsport UK HQ, as well as interesting motorsport artworks and carefully curated displays of race and rally paraphernalia

The affordable Impact Data Recorder (IDR) has been mandated for championship-level motorsport and junior racing, but it could soon be rolled out across the wider UK scene

The life of seatbelts and other safety equipment is traditionally time limited, but the wider use of the IDR might potentially mean this sort of kit could be used for longer periods, if its provenance had been recorded

It's not just about cars and equipment, though. Safety improvements have also been made at many circuits in the UK, especially when it comes to the technology used. Indeed, this is now in line with the sort of thing you see in F1, with light panels supplementing flags, for instance, which has in turn brought further improvements.

Track improvements

'The installation of light panels has meant that circuits have had to increase or improve their infrastructure, the fibre network and the power around the circuit. That means we can also improve and upgrade our CCTV,' says Carter. 'We also have the ability and functionality to bring the light panel signals into the car. At the moment, this technology is only at certain levels of national racing – British F4 for example – but we are looking to see how we can adapt and roll that out across the disciplines.'

Other safety changes Motorsport UK is currently looking at include improving tracking systems on rally cars, while it's particularly interested in a programme the FIA is undertaking on spectator safety using an artificial intelligence camera. The possibility of a rally car going into a crowd of onlookers has long been a concern to governing bodies.

'It would have been pointless to pretend that a sustainable fuel wasn't going to be more expensive on 1 January 2026 than the equivalent fossil fuel'

Ian Smith, technical director at Motorsport UK

'When it comes to the rallying world, it's very difficult to keep spectators within defined spectator zones,' explains Carter. 'We have a safety convoy that goes through looking at the make up of a rally stage, and then we have our safety delegate that goes through. But, once they've gone through, we still see some spectators migrating back onto rally stages. Because they've adapted, they know to not be present when the safety convoy goes through.

'What the FIA have developed is a camera that fits onto the competitors' cars, with an AI programme to identify people. It will then ping information to rally HQ with some photos and a GPS location, which you can place over the top of Google Maps. That gives us more information on what the stage looks like in terms of spectator build up during an event.'

Flags have been supplemented with light panels at many UK circuits, and the installation of the technology and infrastructure improvements required for this has enabled other safety measures to be adopted

Marshals now work with quite high levels of technology. This portable box controls the light panels in the vicinity of the post

Green flag

Keeping motorsport safe for both competitors and spectators is obviously a key role for Motorsport UK, but there is another element to the organisation's work that is also highly laudable, and that is its mission to make the sport in Britain as green as it can possibly be. Recently, the main tenet of this has been the drive toward sustainable fuels. This was looked at in detail in *RE* V35N3, but to recap, the idea was that those series and cars using specialist racing fuels were to be required to use blends with 50 per cent sustainable content by 2026. Since that was written, the results have come in, and this has led to a slight change of plan.

'The feedback from the clubs was that people are starting to be cautious with their spending,' says Smith. 'While they absolutely support the technical elements of the regulation, their ask of the board was please consider the schedule because the clubs' projection is that it's only going to get worse.

'At no point in the process did we pretend that sustainable fuels weren't more expensive. The projections are – based on solid insight and data – that the cost differential will continue to narrow, but it would have been pointless to pretend that a sustainable fuel wasn't going to be more expensive on 1 January 2026 than the equivalent fossil fuel. So that regulation, in terms of implementation date, has been deferred.'

Motorsport UK is now looking at a later date, potentially as soon as the start of 2027, to introduce this regulation (which it should be remembered will only affect a small number of competitors), but it stresses that most were keen for it to happen.

'The majority of people were positive,' confirms David Lapworth, who is best known as the R&D director at Prodrive, but also sits on the Rules Committee at Motorsport UK. 'The compromise is that we're still going to be pushing as many championships as possible to do it, and we're still going to be pushing the suppliers to make sure it's available. We've only changed the glide slope a bit, we haven't actually changed the target.'

Yet while there's been a pause in the roll out of the new sustainable fuel regulation, Motorsport UK remains busy with another component element of its strategy, which is lobbying the government in terms of how these fuels are perceived.

'We are not pretending that even a fully sustainable fuel, in terms of carbon, does not mean emissions at the tailpipe,' says Smith, 'but the problem we've got is that policy

'You want to do a sprint or a hillclimb in your standard [electric] road car, bring it full of electrons, do your three or four runs... there's no need for venues to adjust'

Ian Smith

looks for zero carbon at the tailpipe. It doesn't make any allowance for whether the carbon being emitted is net zero.

'The simple thing about a sustainable fuel is it re-uses carbon that's already in the atmosphere, but there's no leeway within policy to recognise that there are different types of carbon as part of those emissions.

'We've made some really good progress,' Smith adds. 'It's reassuring that there's some real pragmatism and open-mindedness to this. We've got a real opportunity here to use motorsport as a platform to build on this.'

Spark and ride

Sustainable fuel, while still very much the green flagship for Motorsport UK, is just one aspect of environmentally-friendly racing. There is also electric to think about. While London now traditionally stages the FIA Formula E World Championship finale, EV racing has rather fizzled out on the national and club level scene in the UK. The Formula Foundation initiative (see *RE* V33N2), for example, failed to get off the ground, but Motorsport UK says there's still room for battery-powered cars, although this does depend on the event involved. Once again, it's a matter of balance, especially when it comes to the demands that can reasonably be made on motorsport venues.

'The approach we're taking with EVs is to encourage people to make their events accessible to those who want to compete in one. That's not universal, because EVs aren't suitable for every discipline of the sport,' says Smith, 'but where EVs are entirely appropriate – Streetcar disciplines, sprints and hillclimbs, for example – we're encouraging organisers, championships and venues to invite entries from people who want to compete.

'There's certainly no requirement for expensive infrastructure for charging,' Smith adds. 'You want to do a sprint or a hillclimb in your standard road car, bring it full of electrons, do your runs, and then off you go. There's no need for venues to adjust.'

Where venues would need to adjust would be for things like circuit racing, with charging points for cars competing over greater distances, but there seems to be little demand for that right now. Motorsport UK is ready to go on the safety side if there was.

Motorsport UK is evaluating artificial intelligence (AI)-assisted cameras on rally cars, which would help to pinpoint potentially dangerous areas on stages where spectators gather after the safety crews have made their assessments

Formula Foundation, an attempt at national-level electric racing, failed to get off the ground. Motorsport UK believes EVs are currently more suitable for sprint, hillclimb and Streetcar events where road cars can be used

'We've created the basic level safety information and training that's required for our officials and marshals, that's all out there already,' says Carter. 'We've also delivered a programme to our rescue personnel. I think we're almost ready for it, it just hasn't happened.'

Volume control

One advantage of EVs is that they don't make as much noise as regular racecars, which brings us to another environmental issue that motorsport has to deal with more and more these days. 'We set the noise regulations through the national competition rules,' says Smith. 'We do that in collaboration with the venues. Ultimately, it's about local sensitivity. Brands Hatch is subject to the same national competition rules as Anglesey, but the local authority requirements for those two circuits are very different. The constraints that are placed on any one venue are largely based on their agreement with the local council and whatever their noise policy is. The position we've taken around noise, certainly for fixed-venue circuit racing, is the ultimate prerogative lies with the venues, because they're having to manage their obligations with their local authorities.

'That's the basis by which the venues will make their decisions. Brands Hatch, for example, will have a number of noisy days under their contract with the local authority. It's entirely their prerogative what they use them for. When you've got the Brands Hatch Masters Historic Festival that brings a lot of spectators who want to see [and hear] the cars running as they were in period, then they will be granted waivers to run noisy.'

Law and order

While Motorsport UK sets many of the regulations that govern the building and operation of racecars, it also plays its part in enforcing them. That said, it's the clubs and the championships that are at the forefront of this, but it's often when things need to be taken further that the governing body is involved. Fuel analysis is a good example.

'Fuel analysis is about eligibility, which is the prerogative of the club and / or championship. If they want to test fuel

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samples, we'll facilitate connecting them to a lab that will undertake the test against our specification,' continues Smith.

'Similarly, eligibility inspections. We strive for that to be done as much as possible at the event. And the scrutineers, technical commissioners, clubs and championships are perfectly entitled within the regulations to employ specialists. A really good case in point here is all the engine eligibility for Formula 4 is undertaken by Neil Brown Engineering. If they pinpoint a suspected issue, they will report that to the technical delegate for the championship and they will enact the judicial process.'

When it comes to policing technical regulations, it's the scrutineers who are on the front line. There have been some big changes in the way scrutineering is carried out in the UK in recent times, which we have covered in detail in this publication (V34N2). These include Motorsport UK setting up a central database, on which details of each car will be readily accessible, and into which the data recorded on the IDR will ultimately be fed. This, says Smith, is progressing well. But what about perhaps the single biggest issue with scrutineering – and indeed with other roles within motorsport – attracting volunteers?

While Motorsport UK sets noise limits, it's up to the individual circuits to police them, and they will liaise with their local authorities about sound level requirements and restrictions. Exemptions may be made for special 'noisy' events

Voluntary work

'We're dealing with a bit of societal change with people's relationship with spending their free time doing things which don't ultimately receive any payment in return, particularly since Covid,' says Sam Walker, volunteer development manager at Motorsport UK. 'People are generally more selective with what they do. I think changing younger people's view of volunteering and devoting time to something that isn't career-related, necessarily, or related to their degree, is more and more challenging.

'The plan for the next 10 to 15 years is to bring new people in, while also retaining the knowledge, the experience and the skills of the people that are out there currently doing these roles, and making sure that information continues to flow down. Things like scrutineering, for example. How do we retain that knowledge within the sport? How do we make sure we've got younger, enthusiastic people that see that protecting that area of the sport is something worth doing?

'We're dealing with a bit of societal change with people's relationship with spending their free time doing things which don't ultimately receive any payment in return, particularly since Covid'

Sam Walker, volunteer development manager at Motorsport UK

'We've undertaken quite a bit of work in the last four to five months, reviewing everything we have as an organisation on training and recruitment, so we can build a bit of a strategy to get people on board. It's not just scrutineers, it's all the other roles as well. The marshals, the clerks, stewards… Anyone can go and do these things, because we have the training in place to bring you up to the level you need to be.'

With this in mind, there is now a Young Officials Committee at Motorsport UK, which focuses on what volunteering can give back to an individual. As Walker notes, though, it's not just about the young: 'It applies to anyone, of any age, because of the transferable skills that you pick up doing certain things in motorsport. You've got positions of responsibility, you've got event management skills, you've got first aid skills. You pick up lots of things from the roles that you have on an event, which are totally applicable, and useful, in day-to-day life.'

Scrutineering is just one of the ways in which it's possible for volunteers to get close to the action, and Motorsport UK will help with the training that is required. The same applies to marshals and safety crews at the various tracks

Marshal rule

While it might be difficult to recruit volunteers, Motorsport UK should be applauded for the number of boots it has on the ground already, with over 4000 officials signed up and over 10,000 marshals. The latter are the most visible of motorsport volunteers; partly because they're in bright orange, but also because they're right there on the front line when incidents occur.

However, a shortage of marshals has been a problem for a long time in British motorsport. Interestingly, though, marshal recruitment does seem to be improving. While the average age is 52, there are more younger people willing to join the 'Orange Army', as it's affectionately known.

'We've had some 900-odd new marshals during this year so far,' says Claire Kirkpatrick, director of club and volunteer development at Motorsport UK, 'and the majority are in the 19 to 29 age bracket. So we are starting to attract younger people. It's keeping them in the sport, because life can get in the way.'

The pressing question is, then, how can Motorsport UK convince people that volunteering at race events would fit in well with their work-life balance? It's a tough one, but this organisation has already proved it's good at getting the balance right.

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Lawrence Butcher

Platform control

We investigate state-of-the-art racecar damper development, specifically used in international GT racing

By LAWRENCE BUTCHER

The trickle-down effect is present in all areas of racing technology, and dampers are no exception. In the GT classes – GT3 and GT4 in particular – the past decade has seen the capabilities of dampers available to teams increase considerably, often drawing on technologies developed in prototypes and Formula 1.

This development has gone hand in hand with the growth in engineering capabilities of teams at the top of GT3, along with greater availability of tools that allow them to fully understand their chassis packages and properly utilise some of the most advanced damping technology available.

Dampers used in GT racecars can be roughly categorised into two types: monotube and twin tube. Although there are numerous variations within these definitions (and even the odd triple tube design floating around), all have their own benefits and disadvantages. Some suppliers focus on one type, others will offer both.

Damper types

A twin-tube damper features a reservoir into which oil can be displaced as the damper moves through its stroke. As a damper compresses, the damper rod moves into the body of the unit, taking up a small but significant volume. With a standard twin-tube damper, a quantity of oil occupying the same volume as the shaft flows into the reservoir, then back out again as the damper is extended. The reservoir is normally formed by having a twin-walled damper body, with oil flowing into the space between the two skins, its flow controlled by a base valve. The volume not occupied by oil in the outer body is filled with gas to help prevent cavitation.

A monotube damper, by contrast, does not have a secondary reservoir. Instead, the displacement caused by the damper rod moving through its stroke is taken up by a pressurised gas chamber, isolated from the

Unsurprisingly, the Multimatic-built Ford Mustang GT3 uses Multimatic DSSV dampers

Modern GT competition dampers are designed for stability under extreme loads, and for a wide range of car designs

Öhlins TTX dampers are a twin tube design with a solid piston. All damping characteristics are controlled by the valve block in the damper body

damper fluid by a gas separator piston, which is free floating. This layout eliminates issues with aeration of the damper fluid.

The chamber can be located at the end of the damper (increasing its length versus that of a comparable twin-tube unit), but more commonly in racing applications consist of a separate canister located externally to the damper body. This approach allows for the greatest possible damper stroke to be accommodated for a given length. Using an external reservoir also means a greater volume of oil and gas can be used than if they were simply contained in the damper body, helping to combat heat build-up in the fluid.

With both damper types, the traditional approach was that most of the damping was controlled by the main piston moving through the damper body. The damping force is then dictated by the valving within the piston, which governs how the fluid moves from one side of the piston to the other under rebound and compression.

It is here that monotube dampers can have an advantage over twin-tube units. Using a single tube makes it possible to incorporate a piston of greater area within the damper tube compared with a twin tube, which in turn means the shims (which deflect to various degrees when subject to oil pressure) and valves can be made larger, allowing for higher fidelity control.

The larger oil volume available for a given damper body size further helps with temperature control, making for more consistent damper performance. As temperature increases, the viscosity of the damping oil changes, altering both the damping rate and the possibility of cavitation occurring in the low-pressure area behind the piston as it moves through its stroke.

The answer to the latter issue has normally been to use higher gas pressures but, while this reduces cavitation, it also increases hysteresis in the damper, and reduces the fidelity of its operation. The lower the pressure inside the damper, the faster it can respond.

As temperature increases, the viscosity of the damping oil changes, altering both the damping rate and the possibility of cavitation occurring

Through the early 2000s monotube dampers were the favoured option for GT racing, leveraging developments that had been made, notably in touring cars. However, over the past 10 years, twin-tube dampers have come back into vogue, thanks to several developments, including the arrival of solid piston technology from several manufactures.

Quest for control

The complexity of modern dampers is the result of a constant drive to optimise damping rates across different conditions seen on track. That means at high and low speeds, and in compression and rebound.

The aim is to provide perfect platform control, regardless of track surface, maximising mechanical grip and chassis stability around a lap, whereas in the past, dampers were necessarily a compromise between these parameters. The most advanced units can now be tailored to suit almost any condition.

Lawrence Butcher

Damper development in GT3 racing has taken place in the context of cars getting more advanced and race teams, like Manthey here, developing better engineering capabilities

Tuning the damping curve in a conventional damper is achieved by varying the combination of shims within the main piston that control fluid flow through the piston in bump and rebound.

These shims set the primary damping characteristics of the shock, with fine tuning provided by bleed valves at the end of the damper tube, which offer levels of adjustment either side of a base setting.

Both compression and rebound are controlled by the shim stack which, as the name suggests, is a stack of shims of varying thickness. As the damper compresses, fluid is forced through openings in the piston, against the shim stack. The shims will then deflect at varying shaft velocities (the higher the velocity, the greater the fluid pressure exerted on the shims) so, by varying the size of the orifices within the piston, the thickness of the shims and the order they are arranged in, damping force can be altered. The resulting curves are referred to as linear, progressive, digressive or even regressive.

Curve ball

The minutiae of developing and defining damping curves has filled many books, but here's a very brief explanation. A linear curve is as one would expect, damping force increases in direct proportion to damper shaft speed. In a progressive curve, it becomes steadily stiffer as shaft speed rises, while a digressive curve means the damping gets stiffer up to a point, before levelling off. Finally, there are regressive curves, where damping force will ramp up to a given shaft speed, level off, and then decrease again past a certain point.

KW's latest V7 damper features no less than six-way adjustment, high and low compression and rebound, and blow off in both compression and rebound

Naturally, teams are able to adjust damping as a major part of the overall car set-up for a session on track

During low-speed compression and rebound, generally considered to be when the shaft speed is lower than 50-100mm/s, such as when the vehicle is turning, braking, accelerating, or due to high aerodynamic loads, the fluid pressure on the shims is insufficient to deflect them. In these situations, the pressure will generally be routed through a bypass port.

Most manufacturers will incorporate some form of external adjustment system to allow the fluid flow through these ports to be changed, varying the level of low-speed damping. This can either be in the form of a single adjustment valve for both compression and rebound, or separate adjusters for each. A common means of achieving this type of adjustment is via a metered needle valve.

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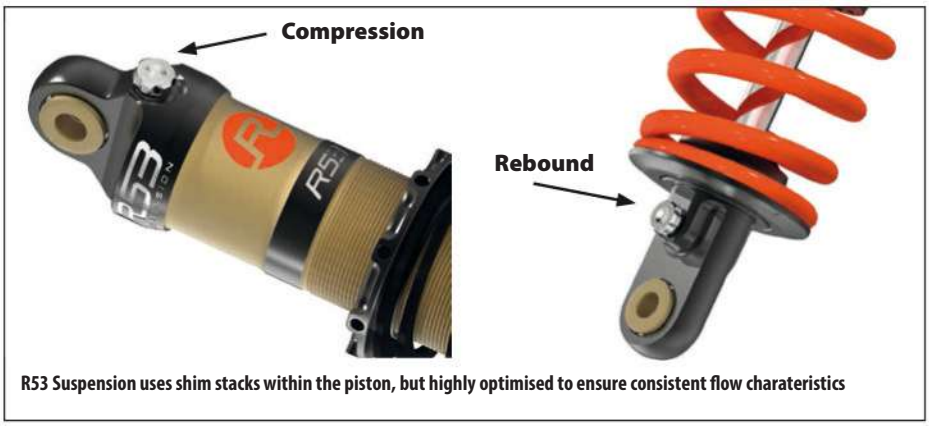

R53 Suspension uses shim stacks within the piston, but highly optimised to ensure consistent flow charateristics

KW's latest offering allows for more aggressive kerb-cutting thanks to intelligent design work

'Traditional' dampers that rely on shim stacks on the piston are still widely used, particularly in lower cost applications where near infinite trackside adjustability is not needed. Indeed, some manufacturers have chosen to stick to this approach and optimise their products for just such an application. However, new technologies such as solid piston, twin-tube dampers (from the likes of KW Automotive and Öhlins) and alternatives to shims such as Multimatic's Dynamic Suspensions Spool Valve (DSSV) have also proved popular.

Starting with the use of solid pistons, these move the control of fluid flow away from the piston and into a valve block. Take KW's solid-piston technology as an example, first introduced in its motorsport dampers in 2017. Here, the piston is used solely to push the fluid. As the damper compresses, the fluid is forced through a manifold that contains the valving for both compression and rebound damping characteristics. The fluid then runs through the cavity between the inner and outer damper shells and into the top of the inner cylinder behind the piston. The upshot is minimal pressure differential across the damper, meaning gas pressure, and consequent hysteresis, can be kept low.

Low-speed damping characteristics are controlled via threaded needle valves, while the high-speed circuits feature a poppet valve tensioned by a Belleville washer, the preload of which can be altered to change the characteristics (on multi-way adjustable dampers). As the valves have a relatively big area and short length of travel between open and closed, the result is a very fast action.

In the case of KW, it supplies a host of different solid-piston dampers to GT teams, from non-adjustable units for spec series through to its latest offering, the V7, fitted to the Lamborghini Temerario GT3. This hi-tech unit features six adjustment modes, high and low speed compression and rebound damping and adjustable blow-off valves for both compression and rebound circuits, designed to facilitate aggressive kerb cutting.

Spool valves

Looking to Multimatic's DSSV system, this also seeks to negate some of the disadvantages of using shim stacks. Instead, the piston incorporates a pair of sleeves, one inside the

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Low and high speed changes of direction are less problematic for a GT3 car than compressions such as that experienced through Eau Rouge, which determine ride height settings

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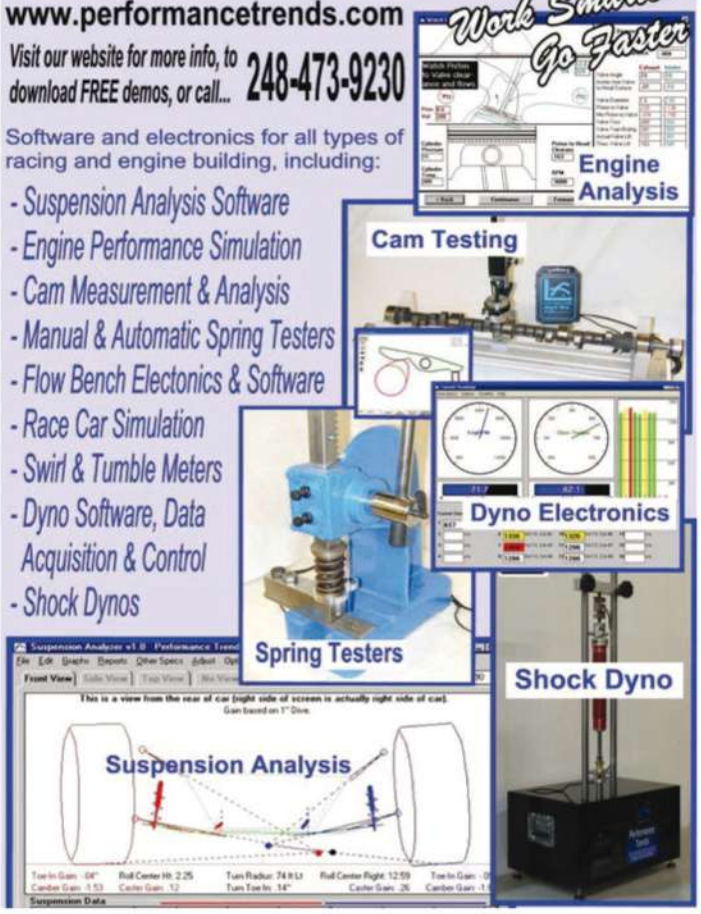
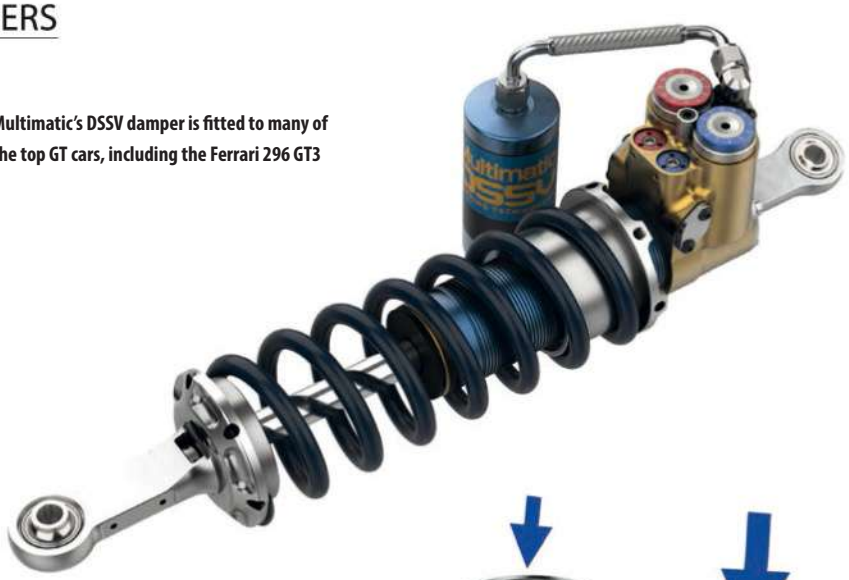


other, separated by a coil spring. At a predetermined shaft speed, the spring compresses and, as the sleeves move, apertures are uncovered that allow oil to flow across the piston.

Two of these 'spool valves' are used, one for compression and one for rebound, and the damping curves are altered by changing spring pressure, along with the shape and size of the orifices. The main benefit of the system, beyond its tuneability, is the valves are not subject to wear and fatigue in the same manner that shims are, ensuring consistent performance even over long endurance races.

These are just two examples of the technologies damper manufacturers have come up with in recent times to help GT teams close in on the perfect set-up.

It should also be noted that there is still space in the series for more traditional damper arrangements using shim stacks. For example, R53 Suspension, which develops bespoke damper systems for both road and race applications, including GTs, has gone to great lengths to optimise the flow characteristics of its damper pistons, which still rely on shim stacks, to ensure efficient flows and pressure balancing, while also providing a broad range of adjustment to allow teams to fine tune from track to track.



Multimatic's DSSV damper is fitted to many of the top GT cars, including the Ferrari 296 GT3

Multimatic's DSSV replaces a shim stack in the piston with a pair of spool valves with springs to control damper behaviour

The through-rod damper allows for the minimum internal gas pressure to be used (sufficient to control cavitation), which brings benefits in terms of damper reaction time

Consistent response

Moving away from damping control, there are other elements found in top-end dampers that help to ensure consistency of control and response, from low-friction seals to material optimisation for weight and stiffness.

One good example is so called through-rod technology, which has found its way into GT racing. Initially developed in F1, these dampers still rely on a conventional damping piston (either valved or solid) but, instead of terminating inside the damper body, the piston rod passes through the damping chamber and out the other end of the damper body.

The result is that the chamber always maintains a constant volume of damping fluid; there is no displacement of the working fluid caused by piston rod travel. This is because no fluid needs to be transferred out of the cylinder, as the volume occupied by the piston and damper rod remains constant.

Consequently, in bump the damper does not have to work against the gas pressurisation of the fluid (in a conventional linear damper, the gas charge contributes considerably to friction and internal pressure). The through-rod damper allows for the minimum internal gas pressure to be used (sufficient to control

Electromagnetic damper dynos

Damper dynos are an invaluable tool to aid with the set-up and fine tuning of dampers, allowing for the units to be cycled through a sweep of shaft speeds, with the damping loads measured to produce a damping curve. They can also be very useful for investigating issues such as aeration of the damper fluid and thermal issues over long runs.

Traditionally, such dynos have been hydraulically actuated, with a piston cycling the damper shaft up and down. However, Lithuanian company LABA7 has developed a new range of dynos, dubbed EMA, which instead rely on electromagnetic actuation up to 120kW.

'There are several advantages compared to hydraulic machines,' says Andrius Liškus, CEO at LABA7. 'You gain in efficiency compared to hydraulics and the maintenance is also lower. EMA requires very little maintenance and there are few parts to wear out.'

The EMA system is also more precise, due to there being no influence from hysteresis in the hydraulic fluid. 'There is a limit to how fast the liquids can move between valves,' adds Liškus. 'A feature of our equipment is that we use super capacitors in the machines, so you do not need high grid power to run them. Even the biggest can be run on 220V, single phase power. So you can get them trackside on a truck, which is not possible to do with a hydraulic machine. The set-up time is also very fast, under 30 minutes from scratch.'

Add in the fact that LABA7's dynos are considerably more cost effective than most hydraulic units and the appeal for race team use is very apparent.

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The long straights at Le Mans make one demand of the dampers, but the twistier turns at the end of the lap can also contribute to better laptimes so compromises must be made

cavitation), which brings benefits in terms of damper reaction time. As the piston is not pre-loaded by gas pressure, the initial resistance to movement of the damper is considerably reduced, increasing sensitivity to very small undulations.

Regardless of the specific system used, the key developments across the cutting-edge dampers available to teams have all been about optimising platform control, in all track conditions, which can vary massively.

Track demands

GT racing is a global phenomenon, taking place across all inhabited continents and on every track type imaginable, from FIA Grade 1 venues to street circuits. With dampers generally homologated to a given car, it is imperative they provide the range of adjustment needed to suit whatever is thrown their way, including a few rather extreme outliers.

The Nürburgring is an excellent case in point. As downforce levels of GT3 cars have increased, so too has the need for dampers that can provide the compliance necessary for the Nordschleife's notorious compressions, while at the same time maintaining a stable aero platform.

KW, which has forged much of its reputation around the 'Ring, highlights that it is the final few millimetres of suspension travel that are most important, noting that there are five points on the undulating German track where a car will run through its entire suspension travel.

Further complicating matters is the fact that the ideal ride height at the Nürburgring is around 30-40mm, in order to make best use of the underfloor aero. However, Germany's motorsport governing body, the DMSB, imposes a minimum GT3 ride height of 70mm in Appendix 2 of its Nürburgring-specific regulations. Running the cars at the ideal ride height therefore requires the use of a soft spring that will compress under load, but this can lead to instability – and complaints from drivers – due to an unsettling transition on and off the bump stops, which have a much higher rate than the springs.

Looking at the Pflanzgarten section of the Nürburgring as an example, damper speeds are very high because the car is landing from a jump over a crest, and then heading up a hill into a right-hand corner. The suspension therefore stays compressed in its last few millimetres of travel.

To keep the car off the bump stops, a stiffer spring could be used, but this would compromise the suspension around the rest of the lap. KW's answer has been to develop a bump stop material with a degree of rebound damping, preventing a rapid transition off the stops and any resulting instability.

Something special

That doesn't mean every damper company has to have a specialist unit, only suitable for use on that one very specific track. Roger Estrada, founder of R53 Suspension, notes, 'For the Nürburgring, the only big difference is that normally you need slightly different stroke dampers. But on the settings side, for our dampers, they are similar to other tracks and perform very well at the Nürburgring, as they do on smoother tracks. Some people will say that's impossible, and you need something special, but I can tell you it is possible.'

With the democratisation of advanced simulation and modelling tools, [teams] are better placed than ever to understand and harness the latest technological advances

The development of dampers within GT racing has progressed enormously over the past decade, but the improvements cannot be viewed in isolation. The engineering clout of the teams has risen over the same period and, with the democratisation of advanced simulation and modelling tools, they are better placed than ever to understand and harness the latest technological advances.

It is not just in the virtual world where tools have been advancing, either. The availability of facilities such as seven-post rigs, through to trackside damper dyno systems (such as LABA7's latest electromagnetic units, see sidebar, p62), chassis engineers have a much wider tool kit to lean on. The result is that the on-track behaviour of a modern GT3 machine and, to a lesser extent GT4, is a world away from that of even a decade ago.

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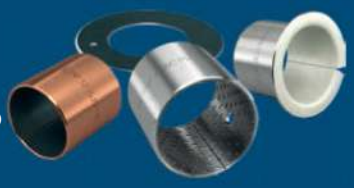

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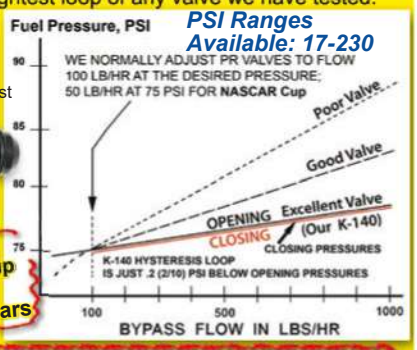

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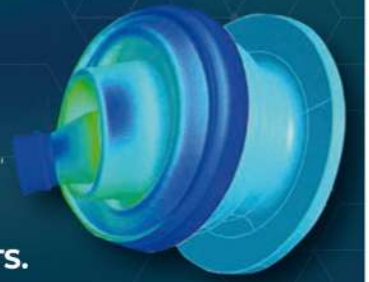

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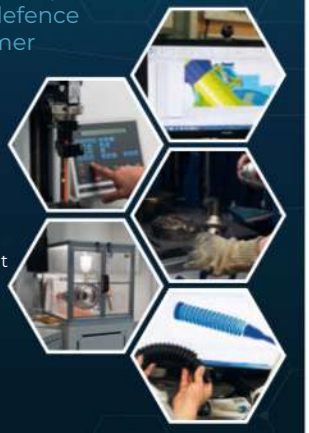

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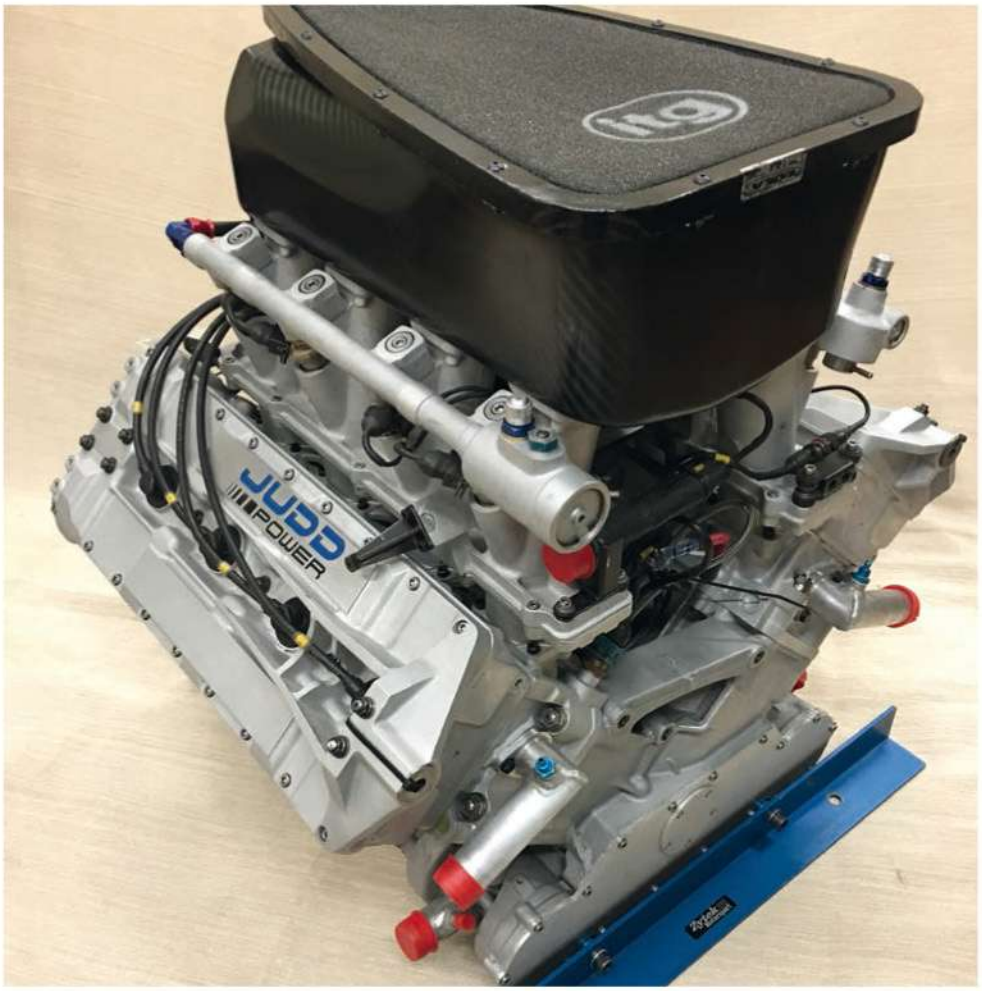
9000rpm rhapsody

An unheralded duet culminated in an engine that became International Formula 3000's soundtrack. This is the story of the Zytek-Judd KV

By JAMES NEWBOLD



Judd Power

The Zytek-Judd KV, pictured as it ran in F3000 spec, is statistically the most significant engine in the history of the F1 junior series

It is hard to envisage Formula 3000 getting off the ground 40 years ago without the proliferation of Cosworth DFVs rendered obsolete by F1's move to turbocharging. Mike Costin and Keith Duckworth's masterpiece was used by every team in 1985, and its 3000cc capacity even lent the nascent series its name. The V8 powerplant kept winning races in what was F1's principal training category until 1993. It would have remained a competitive force for even longer had Cosworth not introduced its successor, the AC, a bespoke engine for the category where revs were restricted to 9000rpm.

Despite the DFV's leading role in the F3000 story, when consulting the statistics, a different picture emerges. It is pushed into the shadows by a powerplant whose own architect admits to preferring his V10 creations.

Although the Zytek-Judd KV's success can't be directly compared to the DFV, since during each of its nine title years it had no opposition, there can be no questioning the significance of an engine that contested 63.59 per cent of all International F3000 races over a 13-year span. All but five of its 101 wins (the DFV notched up 64 in comparison) came between 1996 and 2004, when the KV was chosen as F3000's single-make engine. Prior to that, it held its own, despite consistently being outnumbered against teams using Mugen's MF308 or Cosworth's DFV and AC.

All-round performer

'It was a good solid engine, there was nothing wrong with it at all,' says Paul Crosby, the technical director of Paul Stewart Racing, which ran the KV in 1992 and 1994, co-owner of the Alpha Plus team in 1996 and race engineer for several other outfits.

'The KV just pulled all the way through, so gear ratios were much easier [to optimise]'

Paul Crosby, race engineer, technical director at Paul Stewart Racing and Alpha Plus co-owner

'The AC seemed to be a little bit more top end, with not so much low-down torque. The KV just pulled all the way through, so gear ratios were much easier [to optimise]. On tight, twisty circuits it seemed much better.'

The KV won its first F3000 race on just its third start, at Barcelona in 1992, in the back of Andrea Montermini's Il Barone Rampante Reynard 92D. In 1994, the late Gil de Ferran challenged strongly for the series title and, had the Brazilian's PSR Reynard 94D not been shunted out of the lead at the penultimate round, in Estoril, history may well have looked very differently on the KV.

Eventual champion, Jean-Christophe Boullion (his DAMS Reynard fitted with Cosworth's AC), took full advantage of the situation to win, while de Ferran fell eight points shy of the crown. Speaking in 2022, he too reserved praise for the KV, once mapping work had been completed on its 'very interesting' injector system.

'Once we sorted it out, it was a good engine,' de Ferran remarked. 'It took me to a couple of victories and almost to the championship. Who am I to complain?'

Marriage of experience

Designed by John Judd's Engine Developments concern, and then assembled, serviced and supported by Bill Gibson's Zytek company (today known as Gibson Technology), the KV was a joint effort culminating from many years' experience in racing and racecar engine building. Though it was built for, and found its home in F3000, it was not solely limited to use in that series.

Designed by John Judd's Engine Developments concern, and then assembled, serviced and supported by Bill Gibson's Zytek company, the KV was a joint effort culminating from many years' experience

For the final nine years of F3000's existence, the KV was its sole powerplant. Pictured here is 2004 champion, Vitantonio Liuzzi, in an Arden Lola leading a colourful pack at Imola

Judd, who made his name working on Brabham's world championship-winning Repco V8s, had extensive DFV knowledge from rebuilding them for F1 teams and, in 1985, prepared Ralt boss, Ron Tauranac's, engines as F3000 took its first steps.

With Honda's support, he had branched out into designing his own engines, and the BV was the result. Devised as a smaller and lighter alternative to the DFV, the power unit should have racked up more than the five wins it mustered between 1986 and 1989. Roberto Moreno, for example, was denied three victories with the BV by various Ralt mechanical dramas in 1987, which ultimately cost him the series title.

Development of the BV, which used Zytek's Engine Management System (EMS), was essentially hindered by Engine Developments' commitments in F1, with Williams, Leyton House and Ligier among its customers in 1988. It was left to Mugen, which arrived in 1989 with an engine heavily based on the BV, to break Cosworth's stranglehold. As the Japanese engines proved themselves and became increasingly popular, the BV was gradually phased out.

Gibson Technology

John Manchester believes the KV only lost out to the Cosworth AC during F3000's open era because its rival's reputation allowed it to achieve numerical dominance

Zytek, meanwhile, was a growing force. A specialist in EMS, engine building expertise had been added following the takeover of Alan Smith Racing in 1987.

Zytek then became a key player in Eddie Jordan Racing's 1989 triumph, with Mugen engines prepared for Jean Alesi, and came close to another championship in 1991 when it was responsible for preparing the Mugen engines for Il Barone Rampante driver, Alex Zanardi. Next on the agenda was setting foot on the ladder to becoming an engine design manufacturing company.

John Manchester, now Gibson advisory director but at the time Zytek's engineering manager, remembers Bill Gibson recognising the opportunity. 'He felt the relationship we had with Engine Development was very good,' remembers Manchester. 'We had a meeting with John, Bill and myself, and agreed that we would do a joint venture in terms of a new F3000 engine, which was the KV. We bought the kits from Engine Developments, prepped the parts, assembled and serviced them, and then charged teams for the lease. Spare parts supply was through Engine Developments.'

Partnering with Engine Developments on the KV constituted the next step for Zytek, which had won the 1989 title with Eddie Jordan Racing under the Alan Smith Racing banner. Under its own name, the company came close to securing another championship win in 1991 with Il Barone Rampante's Alex Zanardi, pictured here at Enna

The agreement suited both parties.

'It's a relationship that worked really well,' agrees Manchester. 'It became a highly successful engine and it laid the foundations for where we are today. We have a lot to be grateful for, to the KV, and also to Engine Developments as well.'

Design objectives

Judd's objectives for the KV were twofold. Alongside 'not being any more complicated than necessary' was a desire to keep costs low, so the best elements of the BV were used as a starting point. Several elements dictating the basic structure and strength of the bottom end 'didn't seem to be broke, so we didn't try to fix it,' says Judd.

'We certainly had the same centres and cylinder offset, and we kept the gear train at the back. The vee-angle, the distance between the cylinders, the bank-to-bank offset was all the same, which probably helped us in machining.'

However, where the BV had been badged as a Honda for its first two years, and featured elements made in 'Honda's style', Judd had freedom to devise the KV as he saw fit. The result was fewer castings and separate cylinder heads, what Judd describes as a series of rationalisations: 'We changed the heads, reduced the valve angle, eliminated the covers at the end of the heads of the cam carriers and made those part of the casting.

Gibson Technology

Jim Hibbert (left), pictured with Bill Gibson at Hockenheim in 2003, believes it was a gamble to apply for the single-make deal because no one had any idea how many engines it would be required to supply

Similarly, on the block, we got rid of the cast front cover and put a simple aluminium cover on, which reduced the engine length a bit. We also incorporated the bottom engine mount into the sump casting, rather than being a bolt-on piece.'

Engine Developments also succeeded in lowering the engine's centre of gravity. Eliminating the BV's scavenge slots and galleries down both sides of the sump made the KV more conventional, but was also 'the main thing that let us drop the sump down,' notes Judd. This is attested by Reynard designer, John Thompson, who ran PSR's Didier Cottaz to a best result of a second with a KV at Spa in 1994. He states that the KV's crank centre was 22mm lower than on the DFV in 1992, which Cosworth matched with the AC the following year. 'That's what it was sold on, the whole thing was a lot lower,' Thompson confirms.

This required significant work from Reynard to accommodate it, including alterations to the gearbox, suspension geometry and rear upright, along with a subtle engine cover tweak. Among the KV's other interesting features, Thompson notes the water outlets on the front of the engine presented some further packaging difficulties.

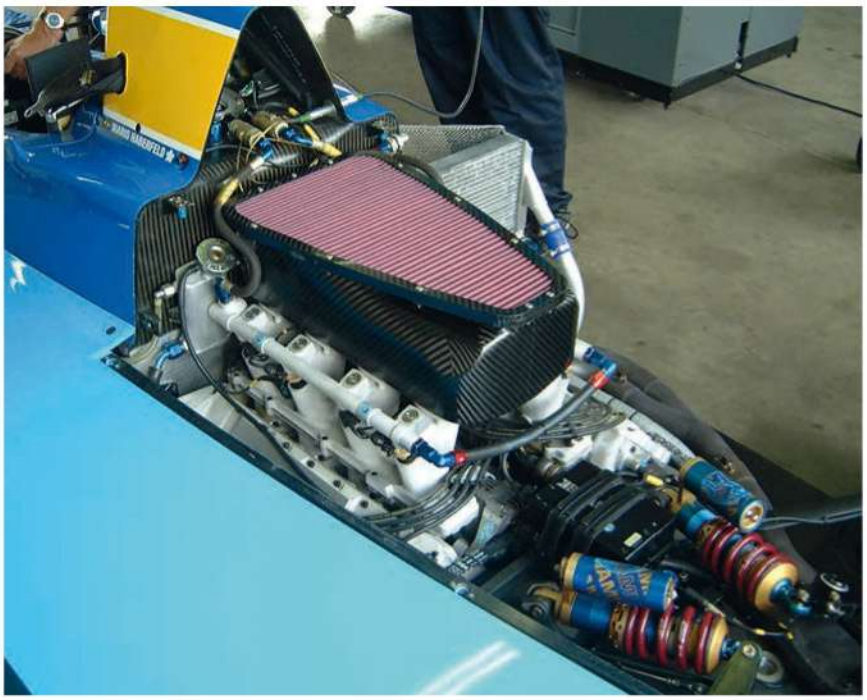
'There wasn't really enough space for it,' he recalls. 'It was an incredibly thin-walled casting and you had to sort of squash it, so it already looked like someone had run a truck over it. I'm still amazed the things held water, because it wasn't pretty!'

Traction action

Zytek received the engines in kits, which contained all the parts needed for the block, bar the inlet manifold system. This was designed and machined in-house at Zytek, where development focused on reducing friction and achieving around 500bhp.

The IBR and PSR teams switched to Cosworth in 1993, while series newcomers, Mythos and Omegaland, embraced the KV, which by that point had traction control (the FIA's decision to ban that technology

Gibson Technology



The KV was modified in 1996 for an FIA-mandated one-make F3000, the idea being to reduce costs and improve serviceability. By 2000, Zytek was running 72 engines. Pictured is Mario Haberfeld's Super Nova example from 2001

Gibson Technology

Parity between engines was ensured alongside Zytek's high level of track support, which was welcome among teams and remembered as being superb. Arden boss, Christian Horner, can be seen in the background here

mid-season came as a relief to the Cosworth outfits). Crosby remembers one KV runner lapping seconds per lap faster in the wet Pau: 'If they'd refined it for dry conditions as well, it would have been very difficult to beat.'

'Zytek's traction control system was in its infancy,' confirms Manchester. 'It wasn't developed to the extent it could have been.' Consequently, he believes the ban on the technology had a negligible impact on the KV's fortunes. He believes Cosworth's AC became the most popular engine simply because the company had a bigger reputation than Zytek at the time, rather than any gulf in quality between the V8s.

'Where the AC probably was superior, they had the best teams and outnumbered us,' recalls Manchester. 'As a law of averages, you'll probably get better results.'

Still, de Ferran came mighty close in 1994 as Paul Stewart Racing returned to the KV, while Max Papis also won with Mythos at Barcelona. Meanwhile, series returnee, Madgwick, became a fourth customer.

Papis enjoyed working with Zytek, feeling it constituted more of a partnership than his former team, Vortex, had enjoyed with Cosworth. That perception was commonplace.

'No one at board level had any interest in that AC engine,' says Crosby. He subsequently found 'no comparison' between Cosworth's customer support and that offered by Zytek, whose engineers proactively embedded themselves with teams. Crosby had previously experienced that while at EJR and cemented his impression in 1995 upon joining Zytek-Judd customer, Magdwick: 'They were really good at customer service and, if there was any problem, they drilled down, found the root cause and solved it.'

'It was highly developed because there was a lot of competition with Cosworth, hence why it got very expensive, and the FIA wanted to stop that and have a single-make contract'

John Manchester, advisory director at Gibson Technology

The same applied even if the problem wasn't directly related to the engine. The reason was simple: getting the car back on track meant the engine was clocking miles and generating income. 'It could have been fuel tank, it could have been fuel pump, anything, but we used to try and help wherever we could,' recalls Jim Hibbert, then Zytek's F3000 project manager and now operations director at Gibson.

Madgwick's Kenny Bräck won the final race of F3000's open era at Magny-Cours in 1995, marking the KV's sole triumph that year as the AC won a third straight title. 'We ended up with a really good spec,' says Manchester. 'It was highly developed because there was a lot of competition with Cosworth, hence why it got very expensive, and the FIA wanted to stop that and have a single-make contract.'

F3000 soundtrack

'Tendering was very different then to what it is now,' Manchester remarks when reflecting on the process by which Zytek-Judd became F3000's sole engine supplier from 1996. He's not wrong. The deal to power rudimentary chassis built by Lola, which saw off Reynard, and would continue using Avon tyres, was agreed between promoter, Bernie Ecclestone, and Bill Gibson over the 'phone. Even more remarkably, their agreement was made without a contract.

'I wouldn't say they were close friends, but Bernie respected Bill and Bill had a great amount of respect for Bernie,' reflects Manchester. 'The whole of F3000, it was all on the word of Bernie. It wouldn't happen today…'

Nonetheless, Hibbert says it was still a gamble to take on the deal: 'We didn't really know how many cars were on the grid in '96. Because the lead time on things like cranks and rods is huge, you have to take a bit of a leap of faith. We really didn't know what it would be like.'

Zytek started out with 54 units in 1996, when the lease price was £25,000 for 2000 miles (or £12.50 per mile). According to Hibbert, this figure went up by 10 per cent every three years as the company's fleet of engines grew. It had expanded to 72 units by the turn of the century, Italian Formula 3000's arrival in 1999 coinciding with unprecedented interest for International F3000 as at least 39 cars arrived at every round. By 2004, the tally stood at 84 units.

Reports that an unnamed car manufacturer would badge the revamped F3000 engine proved wide of the mark, although Manchester confirms the cam cover remained blank in the event of a company seeking branding rights. 'We never actively pursued that,' he says. 'It's a lot easier to talk about it than actually do it.'

Second generation

What Manchester calls the 'second generation KV' was different in a few notable respects, with the intention of lowering cost and improving serviceability: 'The engine was very similar, but all of the intake system from the heads up was a new design, all done by Zytek,' Also by design, power output of the unit was reduced from 500 to 450bhp.

'It was more expensive to do an engine at 500bhp than it was at 450,' Manchester continues, 'so a lot of those expensive components came out. At the same time, because things aren't so close to the edge, it had the effect of making it more reliable. And because it's competing against itself, it doesn't matter [what the output is], so long as it produces that power consistently across all engines. That's the philosophy we've carried with every single-make engine.'

Thereafter, Manchester says the spec was frozen, with any changes that did occur driven by reliability, swapping in more durable components to increase longevity rather than find performance. 'Once you've got a one-make scenario, your only real interest is to keep the engines running, and reliable, and keep cost down,' reflects Judd.

End of an era

It was clear by the end of 2003, though, that smaller grid sizes, due in part to rising competition from the less powerful but more aerodynamically sophisticated World Series by Nissan, and a growing perception that its chassis was increasingly irrelevant in terms of preparation for F1 – meant the writing was on the wall for F3000.

For 2005, GP2 would constitute a new era, as Dallara chassis and Mecachrome engines combined with Bridgestone tyres.

Yet the KV could never be blamed for F3000's downfall. On the contrary, it was a large part of what made the category so great.

With a diligent team of around six to eight Zytek engineers on site at each event – Hibbert reckons he attended 28 races and tests in two consecutive years – reliability was stout and in-race failures proved rare. Engine parity in the single-make era was rarely a topic of conversation either, which allowed race engineers to concentrate on working with drivers and improving the set-up rather than being drawn down rabbit holes. 'I had no doubts that they were equal, or as equal as you can get with two engines,' Crosby recalls.

Appreciation for the KV can also be found at Zytek. Manchester, who has seen Gibson win back-to-back engine tenders to supply LMP2 sportscars, considers the KV 'an extremely important part of our history, because without that we wouldn't be where we are today. We never underestimate the value the KV brought to us.'

'It was very lucrative for us,' adds Hibbert, who agrees with Manchester's assessment that F3000 'was the main focus of the business up until it finished in 2004.'

Enduring legacy

The KV story still didn't end there though. It continued to be used in the former Italian F3000 Championship, which had changed its name to Euro F3000 by 2004, reverted to its Italian identity in 2005 and then re-branded

'[The KV is] an extremely important part of our history, because without that we wouldn't be where we are today. We never underestimate the value the KV brought to us'

John Manchester

THE STATS: Zytek-Judd KV

Championships:	9
Wins:	101
Poles:	102

TECH SPEC

Capacity:	3000cc
Rebuild Interval:	3000km
Weight:	120kg
Maximum power:	520bhp (450bhp in 1996-2004 spec)
Maximum rpm:	11000 (9000rpm in F3000 period)

Judd Power

The BV initially entered as a Honda was a useful starting point for Judd in devising the KV, shown here modified for hillclimb use

'I don't really wish we'd done anything different. It was a good engine for the time, and we're still rebuilding these things now'

John Judd, co-founder of Engine Developments Ltd

Judd Power

The contribution of a what John Judd describes as a 'conservative, workman-like' engine to F3000's success should not be forgotten

again for 2006 as Euroseries 3000. By the time it morphed into AutoGP, however, the KV had been put out to pasture, replaced by a newer, 3.4-litre Zytek powerplant. This would have usurped the KV for 2005 had Zytek been engaged for GP2, but was used instead for the A1 Grand Prix series that pitched nations against each other.

Still running

More recently, the KV has delivered success in hillclimbs, winning the European championship with Italians, Christian Merli and Simone Faggioli. Zytek is no longer involved in servicing the KV, having long since sold off its stock, although Engine Developments retains the Intellectual Property and still provides upgrade packages, including fitting a modern ECU, cylinder heads, camshafts and trumpets. Full rebuilds and dyno testing are also available.

Judd doesn't know how many KVs are still in use, but such is the number of engines on the second-hand market he deems it unlikely Engine Developments would be tasked with producing a brand new KV.

Given the staunch opposition it faced upon entering F3000, Judd agrees that the KV's impact could probably never have been foreseen. Could the engine have been better? 'If we redesigned it now, we'd probably do some things differently,' says Judd, adding, 'We'd further reduce the number of parts, reduce the number of castings, machine more bits from billets, which we probably could have done then if we'd thought far enough ahead, but we didn't. I don't really wish we'd done anything different. It was a good engine for the time, and we're still rebuilding these things now.'

Judd admits he was never as enamoured with the KV as his GV range of V10s, but it is proof that, sometimes, the most successful concepts are those that meet a brief, rather than demonstrate the pinnacle of engineering.

'I can't say I loved it, but it did its job and, ultimately, a lot of engines were made and they had a good record,' Judd concludes. 'It was a conservative, workman-like product. There's nothing wrong with it, and it's still going after 30 years. Isn't too bad, is it?'

Further reading

More information about Formula 3000 and its engines can be found in the new book charting its history by James Newbold. At 416 pages, with 350 colour photographs and overviews of spin-off championships in Japan, Britain and Italy, it is available to order now from Evro Publishing at £75. *www.evropublishing.com/collections/new-in/products/formula-3000*

Although International F3000 came to an end in 2004, the KV lived on in older Lola chassis in the European / Italian championship. Shown is the 2004 championship finale at the Nürburgring

Slip sliding

An examination of the vehicle dynamics of drifting, rear-wheel drive

By DANNY NOWLAN

In 2016, I wrote an article about the vehicle dynamics of rallying. It was a timely piece because very little at that time had been written about it. Time has moved on, though, and recently I had to revisit this subject. One of the things that came up was rallying's close cousins, sprint cars, dirt late models and drifting. I figured now would be as good a time as any to revisit this topic because, let's face it, it's really interesting!

To keep things simple, I will focus here only on rear-wheel drive. The challenge posed when we run on dirt / ice, and when we go drifting, is that we are running completely in the post-stall area of the tyre. To kick things off, let's illustrate this with a bicycle model of a rear-wheel drive racecar, as shown in **figure 1**.

The reason we are using the bicycle model here is partly to keep things simple but also because, as an illustrative model, it can help light the way. For serious calculation purposes, you should use the full model (see chapter five of my book, *The Dynamics of the Race Car*).

The first things we need to know are the slip angles. These are shown by **equation 1**.

$$\alpha_f = \delta_s - \left(\frac{a \cdot r + V_y}{V_x}\right) \qquad (1)$$

$$\alpha_r = \frac{b \cdot r - V_y}{V_x}$$

Where,

α_f = Front slip angle (radians)
α_r = Rear slip angle (radians)
V_x = Forward speed (m/s)
V_y = Sideways speed (m/s)
r = Yaw rate (rad/s)
a = Moment arm from the front axle to the c of g (m)
b = Moment arm from the rear axle to the c of g (m)

In terms of the equations of motion, **equation 2** is what you are looking at.

Where,

m_t = Total mass of the car (kg)
a_x = Longitudinal acceleration of the car (m/s^2)
a_y = Lateral acceleration of the car (m/s^2)

$$m_t \cdot a_x = F_{xr} - 0.5 \cdot \rho \cdot V^2 \cdot C_D A - \left(\delta_s + \alpha_f\right) \cdot F_{yf} - \alpha_r \cdot F_{yr}$$

$$m_t \cdot \left(V_y' + V_x \cdot r\right) = F_{yf} + F_{yr} + \alpha_r \cdot F_{xr} \qquad (2)$$

$$I_z \cdot r' = a \cdot F_{yf} - b \cdot \left(F_{yr} + \alpha_r \cdot F_{xr}\right)$$

Fig 1: Bicycle model of a rear-wheel drive car in post-slip mode

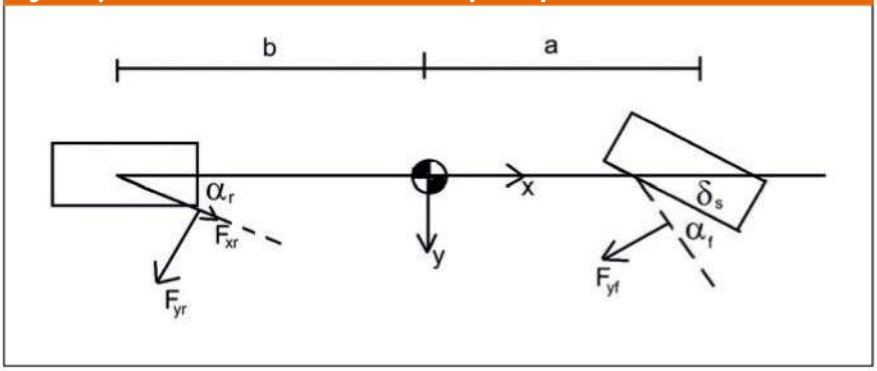
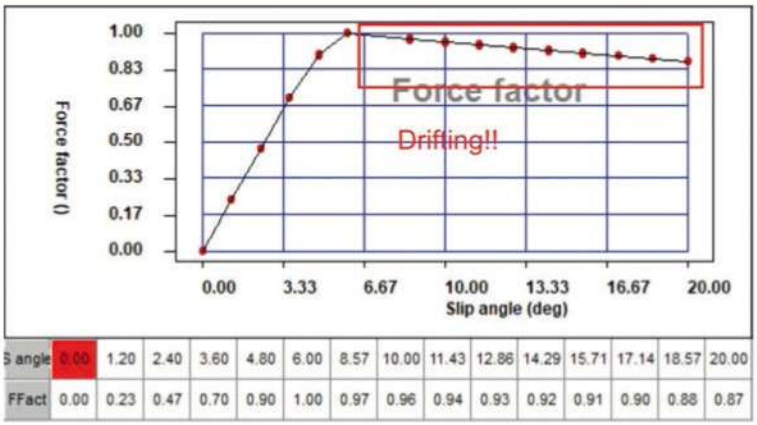


Fig 2: Zone of the tyre when the car is drifting



S angle	0.00	1.20	2.40	3.60	4.80	6.00	8.57	10.00	11.43	12.86	14.29	15.71	17.14	18.57	20.00
FFact	0.00	0.23	0.47	0.70	0.90	1.00	0.97	0.96	0.94	0.93	0.92	0.91	0.90	0.88	0.87

F_{yf} = Total front lateral force of the car (N)
F_{yr} = Total rear lateral force of the car (N)
F_{xr} = Total longitudinal force at the rear (N)
I_z = Rotational inertia of the car (kgm^2)

A couple of observations about what we have done here. You can see we are using small angle approximations. I'm doing this deliberately, for two key reasons. Firstly, it keeps the maths simple; secondly, you can actually push small angle assumptions up to 20 degrees, but I'm nit picking here.

As noted earlier, during drifting, and running on dirt / ice, we are operating in the post-stall area of the tyre. That is the zone illustrated by **figure 2**. The red box shows where we live, tyre-grip wise.

The challenge posed when we run on dirt / ice, and when we go drifting, is that we are running completely in the post-stall area of the tyre

This means we are dealing with a very different animal to circuit / tarmac racing. There, if you are in the zone of the tyre slip curve, something has gone seriously wrong! Or, to quote the late Carroll Smith, you are in the 'idiot area' of the tyre slip curve.

Grip seeking

However in drifting / rallying on dirt and ice, this is where the grip is to be found. So, if we want to be *properly* drifting, we need to start coming up with some numbers to show

where we need to be in side slip velocity, particularly when we are maintaining a constant corner radius and velocity. So, if we have a forward velocity V_x and inverse corner radius iR we can write **equation 3**.

$$r = iR \cdot V_x \tag{3}$$

If we want to be counter steering, the steer angle has to be equal or less than zero. Looking at **equation 1**, and popping in **equation 3**, gives us **equation 4**.

$$\begin{aligned} \alpha_{f\_stall} &= -\left(\frac{a \cdot r + V_y}{V_x}\right) \\ \frac{V_y}{V_x} &= -\alpha_{f\_stall} - \frac{a \cdot r}{V_x} \\ \beta &= -\left(\alpha_{f\_stall} + a \cdot iR\right) \end{aligned} \tag{4}$$

Here, β is the side slip angle (also known as V_y / V_{xj}. While α_{f_stall} is the slip angle at which the front generates its peak lateral force. What this means is the side slip angle for sideways behaviour needs to be less than or equal to this (in practice, it's a negative number that just keeps getting more negative). Which means in order to start drifting, you really need to kick the rear out, and **equation 4** will tell you by how much.

Because we are operating in the post-stall region of the tyre, we can now make a pretty good estimate of what the cornering speed is going to be. Since we know we are operating at the saturation limit of the tyre, we can write **equation 5**.

$$m_t \cdot iR \cdot V_x^{\,2} \approx sat\_f_f \cdot Fm_f + sat\_f_r \cdot Fm_r \tag{5}$$

Where,

sat_f_f = Saturation factor of the front tyre
sat_f_r = Saturation factor of the rear tyre
Fm_f = Traction circle radius at the front axle (N)
Fm_r = Traction circle radius at the rear axle (N)

Note by saturation factor we are talking about what the slip curve levels rise to as the slip angle keeps increasing. This is only an approximation, but it's enough to get us into the right ball park.

At this point, you might be asking what are Fm_f and Fm_r? Well, here's where the four-axis model comes into play. See **equation 6**.

$$\begin{aligned} Fm_f &= Fm_1 + Fm_2 \\ Fm_r &= Fm_3 + Fm_4 \end{aligned} \tag{6}$$

Where,

Fm_1 = Traction circle radius of the front left tyre
Fm_2 = Traction circle radius of the front right tyre
Fm_3 = Traction circle radius of the rear left tyre
Fm_3 = Traction circle radius of the rear right tyre

Fm_1 to Fm_4 can be calculated by the tyre loads using the weight distribution, whatever downforce is being applied. The lateral load transfer I have outlined in so many of my other articles.

The fun stuff

Now that we have these preliminary calculations, we can move onto the fun stuff. When we are solving up to the peak slip of the angle of the tyre, the slip function shown in **figure 2** is dominated by slip angle. We do need to consider the traction circle radius but, for the most part, that will get you by.

When we are full-on drifting and are travelling sideways, the combined slip angle and slip ratio becomes the dominant term. Again, to keep things simple here, I'm going to assume the traction circle radius is circular and the peak slip angles and slip ratios are the same. If that is the case, these approximations for the lateral and longitudinal force on the bicycle model will get you a fair way down the road to understanding the dynamics at play here.

What we are going to do next is pop **equation 7** into **equation 2** and solve for the static condition. See **equation 8**.

$$\begin{aligned} F_{yf} &= \frac{\alpha_f}{\sqrt{\left(\alpha_f^{\,2} + SR_f^{\,2}\right)}} \cdot sat\_f_f \cdot F_{mf} \\ F_{xf} &= \frac{SR_f}{\sqrt{\left(\alpha_f^{\,2} + SR_f^{\,2}\right)}} \cdot sat\_f_f \cdot F_{mf} \\ k_{cf} &= \sqrt{\left(\alpha_f^{\,2} + SR_f^{\,2}\right)} \\ F_{yr} &= \frac{\alpha_r}{\sqrt{\left(\alpha_f^{\,2} + SR_f^{\,2}\right)}} \cdot sat\_f_r \cdot F_{mf} \\ F_{xr} &= \frac{SR_r}{\sqrt{\left(\alpha_r^{\,2} + SR_r^{\,2}\right)}} \cdot sat\_f_r \cdot F_{mr} \\ k_{cr} &= \sqrt{\left(\alpha_r^{\,2} + SR_r^{\,2}\right)} \end{aligned} \tag{7}$$

When we are full-on drifting and are travelling sideways, the combined slip angle and slip ratio becomes the dominant term

Now for the good news, but also unfortunately some bad news as well. Being positive, let's have the good news first. If we take a look at **equation 1**, **equation 8** will be a function of three variables, namely steer angle, side slip angle and slip ratio. The bad news, however, is if we take a look at **equation 8**, we have the k_{cr} rear term populated everywhere, which means this puppy just became a quadratic equation, therefore this is going to be messy.

Fortunately, there is a way through the mess. **Equation 9** shows the first boundary condition you have.

$$\alpha_f \geq \alpha_{f\_stall} \tag{9}$$

That is a 'do not pass go and do not collect $200' situation. For a given corner speed, which you work out from **equation 5**, and a given corner radius, you can then figure out a starting side slip angle. You then solve the yaw and force equations for slip ratio. What is interesting here is the steering angle actually trims for the drag. This is what you are solving for the RWD case.

Solving solutions

Now, here is where things start to get interesting. I did some rough back-of-the-beer mat calculations with a car using the parameters outlined in **table 1**. I started from the slip you would calculate in **equation 4** and swept it out to 30 degrees of rear slip angle. The results are very interesting.

Firstly, if we take a look at rear slip angle vs slip ratio, we don't have a single state solution, we actually have a whole range of solutions. These are shown in **figure 3**. However, when we solve for front slip angle, with the constraint that we must balance drag, **figure 4** tells an even more interesting story.

$$\begin{aligned} 0 &= F_{xr} - 0.5 \cdot \rho \cdot V^2 \cdot C_D A - \left(\delta_s + \alpha_f\right) \cdot sat\_f_f \cdot F_{mf} - \alpha_r \cdot F_{yr} \\ m_t \cdot iR \cdot V_x^{\,2} &= sat\_f_f \cdot F_{mf} + \frac{\alpha_r}{k_{cr}} \cdot sat\_f_r \cdot F_{mr} + \alpha_r \cdot \frac{SR_r}{k_{cr}} \cdot sat\_f_r \cdot F_{mr} \\ &= sat\_f_f \cdot F_{mf} + \frac{\alpha_r \cdot sat\_f_r \cdot F_{mr}}{k_{cr}} \cdot \left(1 + SR\right) \\ 0 &= a \cdot sat\_f_f \cdot F_{mf} - b \cdot \left(sat\_f_r \cdot F_{mr} + \alpha_r \cdot \frac{SR_r}{k_{cr}} \cdot F_{mr}\right) \\ &= a \cdot sat\_f_f \cdot F_{mf} - b \cdot \frac{\alpha_r \cdot sat\_f_r \cdot F_{mr}}{k_{cr}} \cdot \left(1 + SR\right) \end{aligned} \tag{8}$$

Table 1: RWD drift car parameters

Parameter	Value
Mass	1300kg
Front weight distribution	51 per cent
Wheelbase	2.5m
Cornering speed	60km/h (17m/s)
Inverse corner radius	0.029
Total front lateral force	5400N
Total rear lateral force	5600N
Tyre stall angle	6deg / 0.1047rad

Fig 3: Steady state solution of slip ratio vs rear slip angle

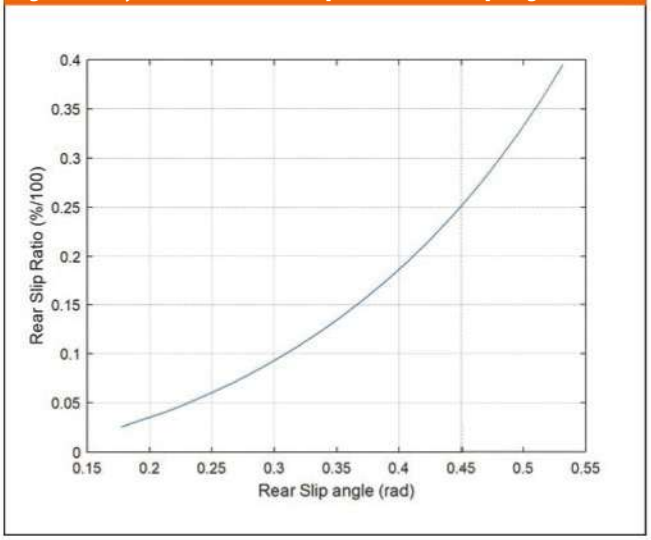


Fig 4: Steady state solution of front slip angle vs rear slip angle

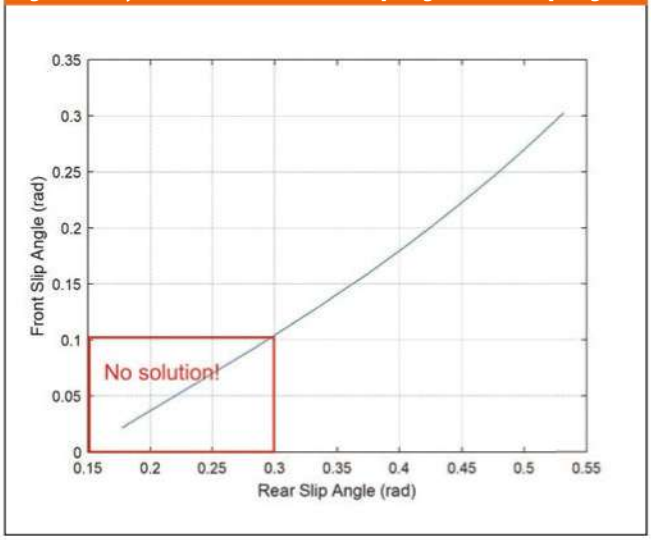


Fig 5: Plot of rear tractive force vs slip angle

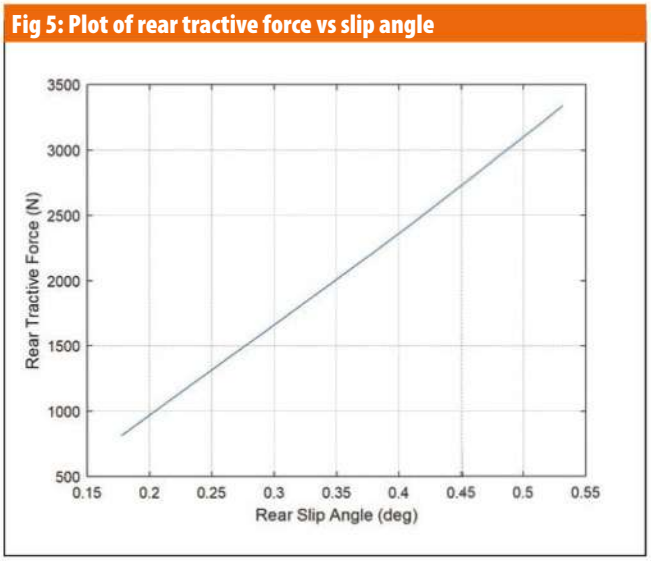
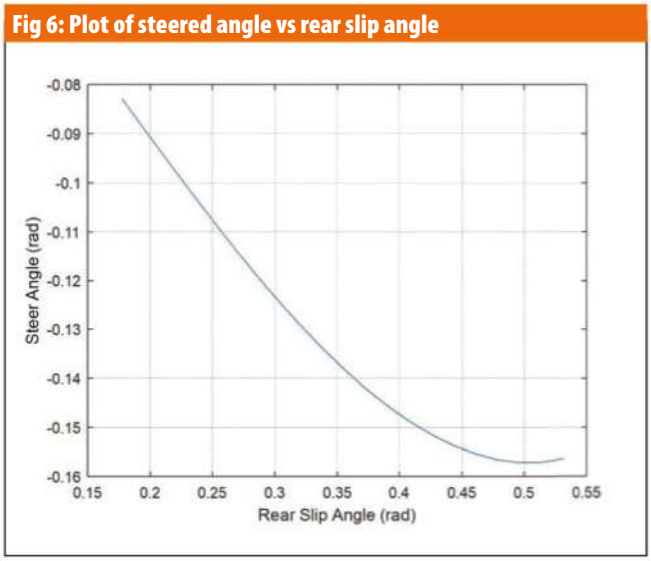


Fig 6: Plot of steered angle vs rear slip angle



Remembering one of our key operational requirements, in order for **equation 8** to be valid, we must have the front tyre force at $sat\_f\_f*F_{mf}$ which means the front slip angle must be equal to, or greater than, the front stall angle of the tyre.

What **figure 4** tells us very clearly is that can only happen once the rear slip angle has exceeded 0.3rad, or 17.20 degrees. That is your entry ticket to the party, and tells you the exact side slip angle you need to be aiming for.

What is also very revealing is when we plot the rear tractive force vs rear slip angle. This is shown in **figure 5**. Granted, this is for a very contrived example, but the power requirements are between 25 and 54.4kW for a very modest corner speed of 60km/h. What this tells us is that for drifting you need grunt, and a lot of it.

The other thing that brings this into sharp relief is if we look at **figure 3**. You are hitting slip ratios of 40 per cent, but you need the grunt for control authority. Remember, once you are in the post-slip condition, throttle is a key control input.

Steering lock also tells a story. **Figure 6** is a plot of steering lock vs rear slip angle. What this tells us is you need between 7.5 and 8.6 degrees of countersteer at the wheels, which is not overly onerous. Note here that as we get towards the upper end, the countersteer reaches a minima. That is tractive force making its presence felt.

Primary concern

So, the question is how much side slip angle do you want to target? In rallying, sprint car, dirt late model and other types of dirt racing, it all revolves around where the grip is. That is your primary concern. In drifting, however, how you want to get the tail out should also be a key focus.

Should this theory be applied to circuit racing? Two words. Hell no! Not only does the shape of the slip curve mean a car is slower once we are north of double the stalled slip angles, but you'll be burning through tyres like there is no tomorrow!

What I have presented here is not the last word on this. I have cheated a bit by using the bicycle model and have made a lot of simplifying assumptions along the way. However, what this analysis has done is to give you the analytical tools to start thinking about drifting mathematically, as opposed to guessing. That is a good thing.

Should this theory be applied to circuit racing? Two words. Hell no! You'll be burning through tyres like there is no tomorrow!

Conclusion

What we have discussed here is a good analytic framework to describe drifting for a rear-wheel drive racecar. Though it is clearly a simplfied model, focusing on the static case of drifting, we have been able to clarify some key things about what the car needs to look like in terms of what it actually needs to drift. While the results are not perfect, they should give some useful food for thought.

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BTCC seeks to boost grid variety

The British Touring Car Championship is seeking to boost the variety of cars appearing on its grid with updates to the new regulations arriving in 2027.

The current NGTC car platform, which has been around since 2011, will continue through the next five-year rule cycle. It means current cars will remain eligible during that period, but the championship has also removed some important restrictions on car model usage and engine choice.

Currently, a car may only be used in the BTCC if the model is sold in the UK. That requirement will be removed from 2027, with models sold overseas permitted if the car manufacturer sells vehicles to the UK market, and if the chosen model respects current NGTC dimensions.

To qualify, the vehicle must use an internal combustion engine as its primary means of power. This means a production hybrid road car may be used as the base, albeit without its electrified powertrain as the BTCC is for ICE racecars only.

Furthermore, engine choice has been opened up so that teams representing a certain car brand do not have to use an engine from that same brand's portfolio. This change in direction means any BTCC-homologated engine can be installed in any BTCC-homologated car, provided the engine in question doesn't feature in more than half the cars on the grid. The exception to that rule is the plug-and-play official TOCA engine from M-Sport. The BTCC currently uses a 2.0-litre, inline-four engine formula.

TOCA

BTCC's new regulations for 2027 are more of a refresh than an overhaul, as the current NGTC car platform will remain valid, but with fewer restrictions on new car model entries and engine choice

Touring car team rises from the ashes after factory fire

When a blaze destroyed its factory, including cars, tools and spare parts, Power Maxed Racing's time in the British Touring Car Championship appeared to be over. Not so. Other competitors in the series quickly rallied around the squad, enabling it to run a pair of Cupra Leons in the mid-August round at Knockhill.

One car was sourced from the current owner of Scott Sumpton's 2024 Restart Racing Cupra, the other was loaned by Un-Limited Motorsport, which gave up one of its entries to the Scottish event as a result.

No one was injured in the incident, and the cause of the fire has not been confirmed, but nine crews from Hereford and Worcester Fire and Rescue Service, as well as police units from Gloucestershire and West Mercia, attended the scene on Saturday 9 August. A HWFRS statement read: 'An industrial unit, around 20m by 100m, was well alight. The incident was sectorised and the fire fought using a compressed air foam system and one main jet. Re-inspections took place during the weekend, and the incident was closed at 15:55 on 11 August.'

The timing of the fire gave Power Maxed less than a week to source replacement cars and prepare them for action. Some of the team's event equipment, such as transporters and awnings, were situated away from the fire and could be used again.

'To watch 20 years of our working life burn in 20 minutes was pretty painful, to be honest,' Power Maxed team principal Adam Weaver told BTCC broadcaster Louise Goodman.

After shaking the cars down, Power Maxed took part at Knockhill. It registered a best result of 15th in the third and final race, courtesy of Mikey Doble who is vying for the Independent class title.

'In some ways, we've probably had the worst week of our life and the best week of our life,' added Weaver. 'We've come from a catastrophic fire to seeing the best in humanity.'

Genesis GMR-001 Hypercar begins track testing

The Genesis GMR-001 Hypercar conducted its first shakedown in mid-August, launching a track test programme ahead of its 2026 FIA World Endurance Championship campaign.

Pipo Derani and André Lotterer took turns to drive the car at Circuit Paul Ricard in southern France, where the team is based. Genesis hasn't said how much mileage they covered at the shakedown, which was followed straight after by more days of running at the same venue. The first track outings came three weeks after Genesis installed the 3.2-litre, twin-turbo V8 engine into the ORECA-built chassis for an in-car fire up in April. Further testing will focus on circuits in Europe, ahead of homologation for the car's race debut at the Qatar 1812km in March 2026.

'Every bit of running we do with the GMR-001 Hypercar in 2025 is extremely valuable,' says Genesis Magma Racing technical director, François-Xavier Demaison. 'The work in preparation that André and Pipo have done on the simulator and during the shakedown means that we have a good starting point for the first tests. Working with our chassis partners at ORECA throughout the testing and development, we can quickly take the data from each test, find a solution and validate it to be able to take full advantage of every moment.'

Genesis Magma Racing

Genesis Magma Racing's GMR-001 Hypercar is built to LMDh regulations, utilising a 3.2-litre, twin-turbocharged V8 power unit in an ORECA chassis

Red Bull to exit World Rally Championship

The FIA has announced that a tender process will be held to find parties interested in taking over the commercial rights of the World Rally Championship. It comes after Red Bull and KW25 took the decision to exit the series after more than a year of negotiations.

No date has been set for the sale, but with multiple parties understood to have expressed interest, and a price tag rumoured to be around the €500m mark, it could take place as early as next year.

The sport's governing body had held extensive talks with the two commercial rights holders ahead of the announcement, which came at the end of August.

'The FIA's priority is to ensure that the WRC is best placed to maximise on this potential and deliver value to all its stakeholders, including drivers, teams, manufacturers, organisers and fans,' said the FIA in a statement.

New regulations that will govern the WRC have been created, and are planned for introduction in 2027.

The financial aspect of the deal will be managed on behalf of Red Bull and KW25 by JP Morgan, the global financial services company.

'The FIA World Rally Championship is the longest-running motorsport series of its kind, one of the most thrilling competitions in the world, with a unique heritage and growth trajectory ahead,' said Malcolm Wilson, FIA deputy president for sport, who set the sale as one of his key objectives when he took up post in June 2025.

IN BRIEF

McLaren Applied has changed its name to **Motion Applied** but will continue to develop electronics systems for motorsport and other industries. The re-brand comes after McLaren Group announced it sold the company to Greybull Capital in 2021.

Lamborghini has put its LMDh programme on pause, meaning the SC63 won't now appear in the 2026 IMSA Sportscar Championship season. The manufacturer admitted that budget and technical demands had 'grown beyond original projections'. Riley Motorsports has been running the car this year, after Lamborghini's original partnership with the Iron Lynx team ended.

TOCA, the British Touring Car Championship promoter, has ended its association with the organiser of the planned **BTCC Junior** series based around a new Chevron-badged car. It was due to begin this year but struggled for entries and was postponed to 2026. Expressions of interest for a new support series will be heard.

Speedworks Motorsport, which runs Toyotas in the BTCC, will join the Fiesta Junior Championship next year under the BTCC Junior Team banner. It will operate up to four cars for drivers aged 14-17, with a view to training them for future BTCC participation.

The return of Chicagoland Speedway after seven years and a temporary track in San Diego are the main additions to the **NASCAR Cup Series** schedule for 2026. Dover will host the annual All-Star Race for the first time, replacing North Wilkesboro which is elevated to a points-paying round. Race action starts with the Clash at Bowman Gray on 1 February.

Racecar extends its deepest sympathies to the family of **Chris Raschke**, director of sales and marketing at ARP, who died in a crash on the Bonneville Salt Flats during the 2025 Speed Week. Raschke was driving the Speed Demon III at more than 280mph during a shakedown run when the accident occurred.

IN BRIEF

Online banking technology company, **Revolut**, has struck a deal with Audi to become the title sponsor of the German marque's Formula 1 team in 2026.

Andretti Global and 3D-printing company **Stratasys** have extended their partnership for the former's IndyCar programme. Andretti has used Stratasys machines to 3D-print components including prototype parts, a steering wheel set-up beam and a cooling shroud for the pneumatic shifting valve block.

Fox Corporation has acquired a one third stake in Penske Entertainment, owner of IndyCar and Indianapolis Motor Speedway. The investment, aimed at raising the profile of the championship, is coupled with a multi-year extension of IndyCar's media rights with Fox Sports.

The in-development **Forze IX** hydrogen-electric prototype made its race debut during a Dutch Supercar Challenge round at Assen in August. The car features two 120kW fuel cells, although only one is currently being used. Cooling and electronics issues impacted the car's run, but the team achieved its goal of making it to the grid. Forze is a student-led race team from Delft University of Technology.

We've seen car brands sell their old racecars before, but **McLaren** is set to take things a step further by auctioning off three of its future competition machines. The lot includes one of the team's 2026 grand prix contenders, the first time an F1 car has been publicly auctioned before its debut. McLaren is also selling a 2026 IndyCar and one of its LMDh cars that will enter the 2027 FIA World Endurance Championship. RM Sotheby's will conduct the auction in Abu Dhabi on 5 December.

Coinciding with its 30th anniversary this year, **JAS Motorsport** is developing its first high-performance road car, alongside Pininfarina. JAS is best-known for building Honda's GT and touring cars.

FIA backs new era for Formula Regional

The European Formula Regional Championship (FRECA) has received full FIA championship status for 2026. It means the junior single seater series will now be known as the FIA Formula Regional Championship. Italy's national motorsport governing body, the ACI, will continue to run the series, in conjunction with the FIA.

An FIA statement declared that the adoption of full FIA championship status for the European series will result in 'better alignment with FIA global standards. This will modernise the Formula Regional category and reinforce its position as a true international benchmark in driver development.'

It added that 'the transition from FRECA in 2025 to the new FIA-supported format in 2026 will mean a complete reset of the technical and sporting package, creating a platform aligned with the demands of today's market and tomorrow's talent.'

The European championship, often abbreviated to FRECA for its affiliation with Alpine, is one of several Formula Regional competitions around the world and sits between F4 and F3 on the FIA's single seater development pathway.

FRECA was established in 2021 after the series absorbed the Formula Renault Eurocup.

FIA

Formula Regional's European series began in 2019 and absorbed the Formula Renault Eurocup in 2021. New second-generation cars are due to arrive in the popular single seater series next year

Gibson reunites with Nissan for new LMP2 PU

The next generation of LMP2 cars arriving in 2028 will be powered by a direct injected, 3.4-litre, twin-turbocharged V6 from Nissan.

Confirmation of the engine layout was given by Gibson Technology, which was recently awarded the contract to supply the prototype category's future powertrain. The process involved Gibson selecting an engine, which it will build at its factory in the United Kingdom, as well as choosing suppliers for the gearbox and electronics.

The unit will replace the normally aspirated, 4.2-litre V8 Gibson has supplied to all LMP2 cars since 2017.

The British company's affinity with Nissan goes back several years. Gibson's LMP2 engine that ran from 2011 to 2016 was derived from the Japanese manufacturer's VK family of V8s. Gibson wouldn't comment on the origin of the future power unit. It has dabbled with turbos in the past, such as the 3.8-litre Nissan-derived V6 unit that powered the Renault R.S.01 GT car.

Further details of Gibson's next LMP2 engine will be released in due course. However, the FIA and ACO requirement was for it to produce up to 420kW (563bhp). In addition to confirming the basic engine layout, Gibson has named Xtrac and Bosch as its suppliers for the transmission and electronic components of the powertrain. The latter will supply a range of components, including an ECU, and a new steering wheel from partner company, MoTeC.

Xtrac, meanwhile, is designing a new transverse gearbox for the task. The British company gained a dominant market share of LMP2 thanks to its supply to the commercially successful Oreca 07 chassis in the previous rule cycle. There, four constructers were licensed to build LMP2 chassis, but that number has been reduced to two from 2028, with Oreca and Ligier Automotive given the nod.

'Our engineering team is already well advanced in the design and development of the new gearbox, which will utilise our latest technology in terms of gearshift mechatronics, and will reflect our commitment to performance, reliability and long-term value for our customers competing at the highest levels of endurance racing,' said David Smith, director of motorsport at Xtrac.

Gibson Technology

British company, Gibson Technology, won the tender to supply the powertrain to the next generation of LMP2 cars, maintaining the position it has held in the prototype series since 2017

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A more connected Europe

What is the impact of the 2025 UK-EU trade deal on Britain's engineers?

The 2025 UK-EU trade agreement marks one of the most significant updates in the post-Brexit landscape to date, with real consequences for engineers working in all sectors across the UK.

Whether you're designing low-carbon systems, working in heavy industry or developing defence technologies, the deal introduces both opportunities and challenges that will dictate how you work, and who you work with. Simon Farnfield, event director at leading manufacturing and engineering networking event, Advanced Engineering UK, which is set to return to the NEC, Birmingham on 29-30 October, explains what the deal means for engineers on the ground.

The agreement is being described as the most comprehensive reset of UK-EU relations since Brexit. It extends the *status quo* on fishing rights until 2038, removes most routine checks on food exports and lays the groundwork for deeper cooperation in defence, energy and youth mobility around the regions.

Unified market

For engineers, the deal suggests a move away from drawn-out uncertainty towards a more connected and predictable working relationship with Europe. One of the standout elements of the new trade agreement is the planned link between the UK's Emissions Trading System (ETS) and the EU ETS. This would effectively create a more unified carbon market, where allowances are recognised across both regions. For engineers working in carbon-intensive sectors such as manufacturing, construction and transport, this important change *should* make life simpler.

By aligning the UK's framework with that of the EU, businesses no longer need to comply with two parallel systems, which means less administrative complexity and fewer regulatory headaches. Plus, there's a major financial upside too, and that's avoiding the EU's Carbon Border Adjustment Mechanism (CBAM). This could save UK exporters, particularly those dealing in steel and cement, up to £800 million annually.

Perhaps most importantly, though, the creation of a single carbon price across the two markets offers greater stability for both regions. That predictability makes it easier for engineers and their organisations to plan and invest in low-carbon technologies with confidence.

Elsewhere, steel remains a backbone of UK infrastructure and a vital part of the country's engineering identity, so it's no surprise the new trade deal gives the sector special attention.

The new trade deal promises much more than just an agreement on tariffs. It opens the door to a collaborative approach that will help foster and develop stronger professional ties in engineering across the United Kingdom and Europe

Under the agreement, British steel exports will continue to enjoy tariff-free access to the EU, crucially avoiding the new regulatory changes and trade barriers that had been looming on the horizon.

In addition to maintaining open market access, the deal also restores the UK's country-specific steel quota to historic levels. That's a big win for stability, giving steel producers and exporters more clarity around export volumes and helping them plan with greater certainty.

Dynamic alignment

Another key takeaway from the 2025 trade deal is the push for closer alignment between UK and EU regulations. While the UK retains the right to set its own rules, this agreement marks a shift towards a more coordinated approach, especially in areas where standards were previously harmonised before Brexit.

For engineers, this means adapting to evolving compliance frameworks. New reporting obligations and technical standards, those tied to emissions management and industrial sustainability, are likely to now come into play. So, whether you're designing systems for energy efficiency or ensuring supply chain compliance, staying on top of these changes will be essential.

Simultaneously, this 'dynamic alignment' has its benefits. Mirroring EU standards can smooth the path for trade and technical collaboration across borders. It reduces duplication, streamlines product development and opens the door for more seamless partnerships, especially in sectors where UK and EU engineers are already closely connected.

One of the more forward-looking proposals is the introduction of a youth mobility scheme. If implemented, it could make it far easier for young engineers to live, study and work across both the UK and EU. Beyond broadening horizons, this kind of freedom of movement encourages knowledge sharing, skills development and stronger professional ties between emerging talent on both sides of the Channel.

There are also opportunities emerging in defence. With the UK and EU set to deepen their cooperation in security and military matters, UK engineering firms may gain access to the EU's €150 billion rearmament programme. That kind of investment brings the potential for major new projects, from advanced systems design to large-scale infrastructure development, which offers engineers exciting challenges and the chance to contribute to international initiatives.

Opening doors

The 2025 UK-EU trade agreement is more than just a policy, it's a recalibration of how UK engineers engage with Europe. From the integration of emissions trading systems to safeguards for steel and closer regulatory alignment, the deal offers a framework that could help engineering businesses remain competitive while opening doors to new collaborations and markets.

With change comes the need to stay ahead. Engineers and industry leaders need to remain agile, informed and ready to adapt. One of the best ways to keep pace is by staying connected to the wider engineering community.

Subscribing to the *Advanced Engineering* newsletter is a simple way to do that. And, of course, there's no substitute for face-to-face collaboration. Advanced Engineering 2025 is taking place on 29–30 October at the NEC, Birmingham, so why not come along? Register now to attend this year's show in person. *www.advancedengineeringuk.com*

Racecar engineering
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What's the point?

Why the Garage 56 entry at Le Mans should return to its roots

The 24 Hours of Le Mans irregularly permits a Garage 56 entry, designed to accept new ideas and emergent technologies. Due to its experimental nature, the normal rules do not apply – the car may run whatever its manufacturer wants to prove or showcase, provided this is done safely. The only criterion is that the car doesn't win the race outright. This involves complying with pre-set parameters that would normally put it behind the top class and around LMP2 pace.

Introduced in 2012 for the Nissan DeltaWing, a concept that was originally proposed as an IndyCar, the Garage 56 concept has since morphed into something rather different. There were plans to use it to run new powertrains, such as the Nissan ZEOD RC, which became the first electric car to complete a lap of Le Mans in 2014, or a rumoured Audi that would run on diesel developed from crops grown in the United States. Frédéric Sausset, a quadruple amputee, completed the 2016 edition in a specially adapted car, which was an incredible human achievement but not what the category was traditionally about.

NASCAR revival

After a few years off, the Garage 56 entry slot was revived when NASCAR used it to field a Gen 7 car. This was a massive crowd pleaser, but again not what the category was originally for. I had a conversation with ACO president Pierre Fillon and encouraged him, unsuccessfully obviously, to increase the number of Garage 56 entries for future editions. There should be five places on the grid, for cars that would run such ideas as active suspension. That would allow a lower ride-height on the straight, reducing drag, followed by a raise for the final chicane. It could also permit different fuels, including solid-state hydrogen with replacable packs rather than traditional refuelling; lighter cars with smaller capacity engines; new materials in bodywork, or non-stressed areas of the car. Tyre companies could experiment with much higher amounts of recycled materials. There is so much that could be tried out – a look through any Formula Student entry list should throw up some ideas. Garage 56 should be about running an innovative concept knowing that it would be about validation, rather than victory.

Tyre companies could experiment with much higher amounts of recycled materials

The idea of running a Super GT car at Le Mans looks good on paper. It would be another crowd pleaser, there is no doubt about that. A GT500 car would look and sound incredible, but in its current form it is faster than the current Hypercars so would need to be slowed down to at least finish behind the top class, and perhaps LMP2 as well.

Not that this is a major barrier; NASCAR and Hendrick Motorsports developed their car to an incredible level to get it to run in 2023. The car was a worrying combination of being fast in a straight line, and heavy, which meant braking distances were longer than might be expected. The fear was that the car would whistle past, say, an LMP2 on the straight but hit the brakes so early that the prototype might plough into the back of it. Another wag wondered what would happen if the brakes failed – how many chicanes would the car take out? They solved the problems, the car raced cleanly until Sunday morning, and it is widely considered to have been a success story.

The GT500 car is based on a chassis that was jointly developed between DTM manufacturers Audi, BMW and Mercedes in 2012. The German marques believed they could not only increase their customer base by selling their new cars to the Japanese, but also encourage Japanese teams to race in Europe. There was no realistic prospect of that happening, of course. Super GT organiser, the GTA, wanted to keep its tyre war going, which flew in the face of the DTM and its effort to control costs. The GTA also wanted to retain engineering challenges for its own teams, and Honda added to the complication by running its car with a mid-mounted engine. There was also the slight issue of there being no real volume market for the GT500 cars in Europe; they could only race in the DTM. For the German brands there was more chance of selling in Japan, but they were able to go there with GT3 cars anyway.

Nissan return?

If the GT500 proposal goes ahead, I suspect it would appeal to Nissan. It had a rather troubled experience with its LMP1 car, spending a full season budget on a single race, which put the company off endurance racing for a while. Now Nissan is coming back with the LMP2 engine deal via British company Gibson, and might want more.

The ACO originally said that the Garage 56 entry slot should be for manufacturers bringing technologies that could be used in its top class at a later date, and would only grant an entry if the company later committed to an LMP1 project. That's how Nissan ended up on the grid with its GT-R LM Nismo, after the DeltaWing and ZEOD. If Garage 56 is not going to be used for its original purpose of showcasing new tech, then at least it could give a proud company such as Nissan a chance.

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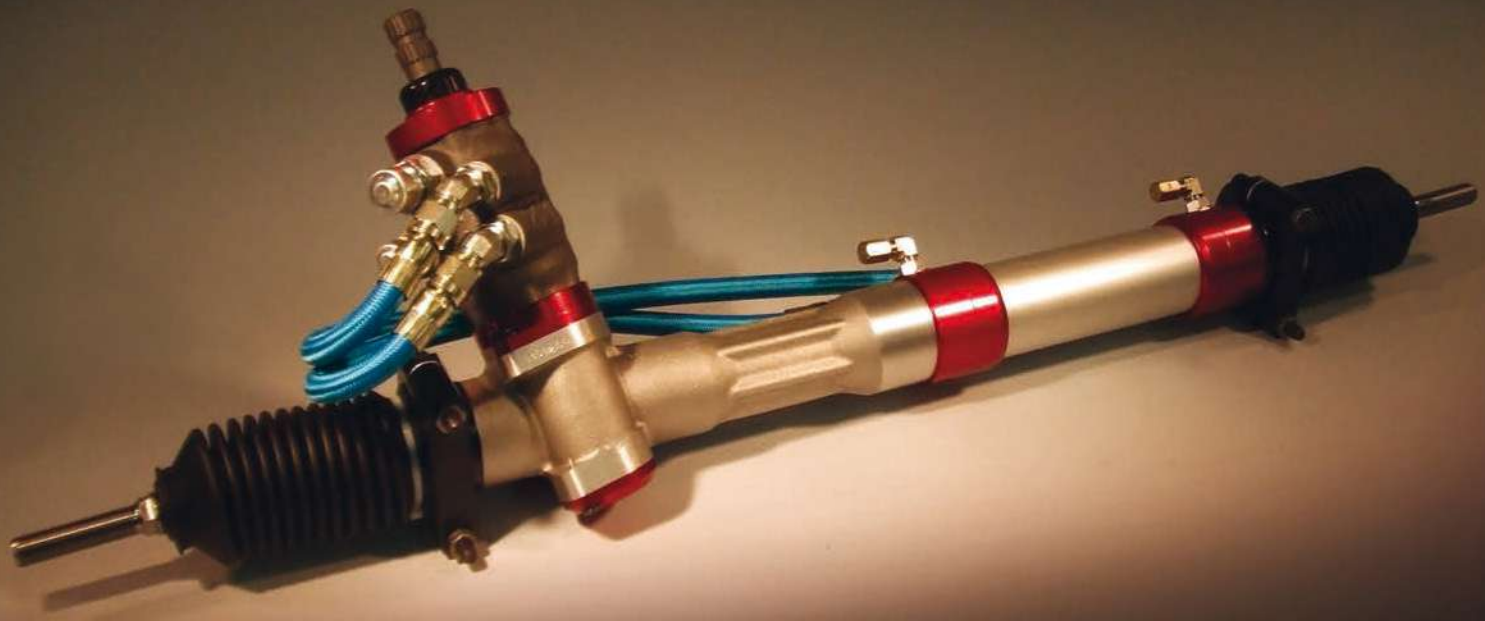

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